EFFECTS OF CREEP FEEDING, ZERANOL, AND BREED TYPE ON REPRODUCTION AND MATERNAL ABILITY OF BEEF COWS

By

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To my parents
Januàrio and Nanà

To my late parents-in-law
Domingos and Maria

To my wife and children
Ana, Fernanda, Gustavo, Guilherme, and Suzana

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by

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Data collected on 92 heifers from Angus (A) and Angus-Brown Swiss F_1 (F_1) dams and sired by Brahman (B) and Romana Red (RR) bulls were used to study the effects of creep feeding and preweaning zeranol implants on growth and reproductive performance of beef females. Effects of treatments on yield and composition of milk produced by the heifers and the preweaning performance of their calves were determined from 97 cow-calf pairs. Creep feeding treatments studied were no creep (NC), creep feeding from 146 days of age to weaning (SC), and creep feeding from 56 days of age to weaning (LC). Part of the heifers in each creep group received a 36 mg implant of zeranol at 56 days of age and another 36 mg implant 90 days later.

Creep feeding significantly increased heifer weight through palpation for third pregnancy, but did not significantly affect pregnancy rate, average milk production or composition, or weight, age, hip height and condition score of their calves at weaning. The LC significantly depressed average milk production and weight of the calves at milking days, in comparison to SC, but SC and LC groups did not differ ($P < .10$) for calf weaning weight, because LC heifers weaned older calves. Zeranol implanted heifers were heavier ($P < .10$) up to palpation for first pregnancy, tended to have a higher pregnancy rate as yearlings, and had a lower ($P < .10$) pregnancy rate in the third breeding season. Zeranol treatment did not affect ($P > .10$) yield or composition of milk or calf traits. A higher proportion of B-sired heifers was cycling at the beginning of the first breeding season, and B-sired heifers were heavier at the beginning of the first breeding season, produced more ($P < .001$) milk, and weaned significantly heavier, older, taller, and fatter calves than RR-sired heifers. The RR-sired heifers produced milk with higher percentages ($P < .001$) of fat and total solids than B-sired heifers. A higher proportion of heifers from F_1 dams was cycling at the beginning of the first breeding season. These heifers were significantly heavier up to the second palpation for pregnancy, produced more milk, and weaned significantly heavier, older, and taller calves than heifers from A dams.

INTRODUCTION

In commercial cow-calf operations, calf weaning weight together with weaning rate will determine the gross income. Heifers that are too lightweight at weaning are unlikely to reach puberty before the beginning of the breeding season. Also, in the purebred beef cattle industry, the commercial success of the operation and the marketability of breeding bulls are directly related, in most cases, to the ability of the animals to grow rapidly at early ages. Creep feeding is one of the practices used to increase calf weaning weight and has been considered profitable by some authors and unprofitable by others. Zeranol implantation is generally considered to be a profitable way to increase weight gain of calves during the preweaning period, as well as in other phases of growth.

The close relationship between live weight and onset of puberty suggests that creep feeding and zeranol, through their effects on weight gain, could increase the proportion of heifers cycling at the beginning of the breeding season, thus increasing pregnancy rate. However, studies have shown that postweaning zeranol implants tend to depress reproduction. Little information exists on the effects of preweaning zeranol implants on future reproduction and productivity. Some research has shown a depressive effect of creep feeding on future reproduction.

Studies on the effects of creep feeding on future maternal performance have shown that creep-fed heifers wean lighter weight calves, as cows, than do noncreep-fed heifers, due to a lower milk production by the creep-fed animals. Little and conflicting information exists on the effects of zeranol on future maternal ability of heifers. Nursing calves often are implanted with zeranol before selection of replacement heifers is made, and creep-fed heifers have been maintained as herd replacements.

This study was conducted to evaluate the combined effects of zeranol and creep feeding on postweaning development, reproduction, and maternal ability of crossbred beef heifers.

LITERATURE REVIEW

Treatment Effects on Growth and Reproduction

Creep Feeding

Creep feeding effects on preweaning growth

Creep feeding does increase the weaning weight of calves (Nelson et al., 1953; Furr and Nelson, 1959; Burns and Koger, 1963; Wilson et al., 1966; Hunsley et al., 1967; Anthony and Starling, 1968; Holloway and Totusek, 1973b; Stricker et al., 1979; Martin et al., 1981; Hixon et al., 1982; Prichard, 1983). The increase in weaning weight due to creep feeding varies from about 7 kg (Burns and Koger, 1963) to 40 kg (Furr and Nelson, 1959). Furr and Nelson (1959) concluded that creep feeding resulted in greater improvement in the weaning weight when the dams were maintained under low levels of nutrition.

Holloway and Totusek (1973a) observed higher values for wither height at weaning in creep-fed calves in comparison to those noncreep-fed, and Wilson et al. (1966), Holloway and Totusek (1973a), and Prichard (1983) observed that creep-fed calves had higher average condition scores at weaning.

To evaluate the overall effect of creep feeding, some indirect effects have been measured. Positive effects of creep feeding on weight of the dams were observed by Anthony and Starling (1968) and Prichard (1983). On the other hand, Burns and Koger (1963) reported an advantage in weight in favor of dams of noncreep-fed calves. Prichard (1983) concluded that, even though creep feeding improved the dam's weight gain and condition score in the period corresponding to the breeding season, creep feeding did not affect pregnancy rate. Stricker et al. (1979) observed a small increase in the carrying capacity of the pastures when calves were creep-fed.

There is not a perfect agreement about the profitability of creep feeding. Wilson et al. (1966), in an experiment in which the calves and their dams were maintained in dry-lot, compared the profitability of creep feeding to no creep feeding and early weaning. They concluded that cow-calf feed costs per kilogram of calf gain were lowest for the creep-fed groups. Similarly, Hunsley et al. (1967) concluded, from a 4-year study, that creep feeding was profitable in all years the study was conducted. On the other hand, many authors concluded that creep feeding was not profitable (Nelson et al., 1955; Furr and Nelson, 1959; Temple and Robertson, 1961). Preston and Willis (1974), based on data from the literature, stated that the comparatively lower feed conversion by creep-fed animals, in comparison with the values observed in feedlot, made creep feeding very unlikely to be profitable. Hargrove et al. (1983), however, observed feed conversion values of 6.7 and 5.1 for long- and short-term creep-fed calves, respectively. These values were similar to those observed during the feedlot finishing phase.

Creep feeding effects on post-weaning growth

The post-weaning weight gains of creep-fed calves, relative to gains of noncreep-fed calves, will depend on the post-weaning nutritional level. Martin et al. (1981) observed that creep-fed male calves maintained until one year of age the advantage they had at weaning over the noncreep-fed calves. However, noncreep-fed heifers, which weighed 10 kg less than the creep-fed heifers at weaning, were 7 kg heavier at one year of age. The reason for the different growth patterns between animals of the two sexes was that the males were fed a high energy feedlot diet postweaning, and the females were submitted to a low energy diet to grow at the rate of .5 kg daily. Similar results were reported by Burns and Koger (1963), who observed that for male calves maintained in the feedlot, the weaning weight difference in favor of creep-fed animals was maintained, but for the replacement heifers this difference was erased by the time they were 18 months old. Hunsley et al. (1967), working with male calves which were put in the feedlot for fattening after weaning, observed that creep-fed calves continued gaining faster during a 2-week adjustment period after weaning, required fewer days to reach slaughter requirements, and produced significantly more kilograms of chilled carcass per day of life than noncreep-fed animals. On the other hand, Holloway and Totusek (1973b) reported that differences in weaning weight and wither height observed at weaning in favor of creep-fed heifers did not exist when the heifers were 2 years old, and values for condition score, which were higher at weaning for creep-fed heifers, did not differ at one year of age.

Creep feeding and reproduction

The level of nutrition of heifers during the rearing period should receive special attention to permit them to have optimum, economical performance as cows. Age at first estrus has been shown to be delayed by a low level of nutrition (Hanson, 1956, Crichton et al., 1960, Wiltbank, 1993). In several rearing experiments, the authors concluded that onset of puberty occurred at about the same liveweight, regardless of the level of energy offered (Crichton et al., 1959; Crichton et al., 1960; Reid et al., 1964). Wiltbank (1993) showed that the onset of puberty was highly influenced by the weight of the heifer, but that age also was an important factor. The influence of age on onset of puberty was also shown by Ferrell (1982). He observed that heifers fed low nutritional levels reached puberty at more advanced ages, but at significantly lower weights, than those receiving normal or high levels of nutrition.

The observed relationship between body weight and onset of puberty emphasizes the importance of providing heifers enough feed to permit them to be cycling before the beginning of the breeding season. As pointed out by Ferrell (1982), it is not only important that heifers breed and conceive, but for maximum efficiency, they should breed and conceive early in the breeding season.

Working with 603 Hereford heifers under range conditions in Australia, Cohen et al. (1980) developed the regression equation for predicting percent of heifers reaching puberty at specific liveweights, to determine the ideal rate of gain for growing heifers. They predicted that 50% of the heifers would show estrus at 231 kg and 95% would show estrus at 280 kg liveweight.

Results in the literature show that high weight gains by heifers, during some phases of the growing period, may have detrimental effects on their future performance as cows. The optimum feeding program for the herd must be one that permits as high a percentage as possible of heifers cycling at the beginning of the breeding season, avoiding, however, overfeeding during the critical periods.

Wiltbank (1983) reported that heifers weighing about 320 kg at the beginning of the breeding season weaned 19% more calves at first calving than those weighing about 270 kg. Also, 28% more cows that had been first exposed at the weight of 320 kg became pregnant in the second breeding season. These results were heavily influenced by the cycling status at the beginning of the first breeding season, but they do not permit any conclusion about the ideal rate of gain during the different phases of the growing period.

Analyses of results comparing the effects of increasing levels of nutrition on reproduction must take into account the period of life in which high and low levels of nutrition are fed and how extreme the levels are. There is good evidence that high nutritional levels in early life tend to depress fertility, but in a later phase of the growing period, relatively high levels of nutrition may not have adverse effects and may even be beneficial. High postweaning gains have been shown to increase the percentage of heifers reaching puberty before the beginning of the breeding season, and a nutrition level which produces a good body condition at parturition increases the chance of rebreeding. Short and Bellows (1971) studied the relationship between postweaning weight gain, age at puberty, and reproductive performance of heifers. The animals were fed to gain either .23, .45, or .68 kg per day, during a 150-day period. Increasing the feeding level decreased the age at puberty, so that fewer of the heifers fed to gain .23 kg per day (7%) and of those fed to gain .45 kg per day (27%) reached puberty by the beginning of the breeding season, as compared with those fed to gain .68 kg per day (83%). Pregnancy rates were 50% for heifers on the low gain treatment and 87% for those on the medium and high gain levels. Similarly, Ferrell (1982) compared the effects of three rates of daily gain, .40, .60, and .80 kg, on future reproductive performance of heifers. He concluded that there was no significant effect of rate of gain on pregnancy rate, but when he associated condition score with pregnancy rate, he concluded that there was an optimum condition score above or below which pregnancy rate tended to decrease. In another study involving levels of nutrition postweaning, Pinney et al. (1972) studied the effects of three supplemental levels of protein on future reproductive performance of Hereford heifers. The heifers were maintained on native pasture and received 60, 120, or 200% of NRC recommended daily protein allowance during their first two winters. Percentage of calves born and weaned favored cows receiving the lowest supplemental level.

Studies in which low and high nutritional levels are imposed just after birth and continued until the first parturition usually show adverse effects of high nutritional levels on reproduction. Reid et al. (1963) fed heifers from birth to first parturition either 62, 100, or 146% of recommended total digestible nutrients (TDN) (Morrison, 1956). After first calving, the animals were fed according to their nutritional requirements. The authors observed that sterility was the main reason for culling cows fed the high TDN level. In a similar study, Hanson (1956), working with twins, fed one twin of each pair from 1 to 25 months of age according to the requirements for growth. The other twin was fed either 60, 80, 120, or 140% of the level given to the control twin. Nutritional levels above the control depressed fertility.

There is not a perfect agreement about the effect of high preweaning levels of nutrition on future reproductive performance of heifers. However, experimental evidence indicates that the preweaning phase might be a critical period in which overfeeding may depress fertility. Etienne and Martin (1979) studied the effects of weight and weight gains of Angus heifers at different periods of their growing phase on their performance as cows. Fifty percent of the heifers had been creep fed. To evaluate the effect of weaning weight on future reproductive performance, the heifers were divided into four groups of equal size, from the heaviest to the lightest, in such a way that the first group contained the heaviest heifers and the fourth the lightest. The authors concluded that the heifers in the second and in the third quartiles had higher pregnancy and weaning rates than those in either extreme quartile, and suggested that the heaviest heifers had a poor performance due to the negative effects of fatness on conception. Similarly, Martin et al. (1981), in a long-term study on the effect of creep feeding on future reproductive performance of heifers, concluded that creep feeding had detrimental effects on reproduction, expressed as number of calves weaned per female during her lifetime. On the other hand, Hixon et al. (1982), Holloway and Totusek (1973b), and Little and Key (1979) did not observe negative effects of creep feeding on future birth and weaning rates

Zeranol

Zeranol is a derivative of zeralenone, a metabolic product isolated from the fungus *Giberella zeae* (*Fusarium graminarum*) (Shipchandler, 1975). It is used as a growth stimulant implant and is commercialized under the trademark RALGRO®. It is cleared for calves under 180 kg (Corah, 1980) and is used during the suckling period and during the growing and fattening periods in cattle destined for slaughter.

An implant of 36 mg of zeranol is used irrespective of the age of the animal and can not be implanted within 65 days of slaughter (Corah, 1980). Zeranol is not cleared for breeding animals (Corah, 1980, Staigmiller et al., 1983). However, since zeranol has been implanted by many producers in calves before replacement heifers have been selected, research has been designed to study its effect on reproductive performance of heifers (Morrow, 1984).

As has been observed for other growth stimulants, the response to zeranol implants is greater under better nutrition (Prichard, 1983, Morrow, 1984), and its effect also depends on factors that affect potential of the animal for growth, such as breed (Prichard, 1983) and sex (Ralston, 1978; Prichard, 1983; Steigmiller et al., 1985)

Zeranol has been implanted in suckling calves as early as birth (Ralston, 1978, Simms, 1983, Unruh et al., 1983) and around 2 to 3 months of age (Ellington et al., 1978; Pourrain, 1983; Prichard, 1983). The results in the literature on the effects of zeranol on the weight gain of sucking calves are, many times, conflicting. However, when the results are considered within a given sex group some consistency is observed. In most experiments, in which zeranol was implanted in steers or heifers, positive results in weight gain were observed (Corah, 1980, Prichard, 1983, Simms, 1983, Staigmiller et al., 1985), and reimplanting normally caused additional gain. Some authors, however, did not find significant increases in weaning weights of implanted steers (Ellington et al., 1978, Unruh et al., 1983). In the case of sucking bull calves, most experimental results showed a depressive effect or no effect of zeranol implants on weight gains (Walston, 1978, Brethour and Schambacher, 1983, Unruh et al., 1983, Staigmiller et al., 1985), but positive effects of zeranol on weaning weights of bulls have also been observed (Walston, 1978).

Conflicting results have been reported on the influence of additional gain due to zeranol in the preweaning phase on postweaning gain. Staigmiller et al. (1983) reported that the additional gain of implanted heifers over the controls, during a period in drylot, was maintained in summer pastures. On the other hand, Hargrove et al. (1983) reported that steers implanted preweaning were significantly heavier at weaning but did not maintain the weight advantage through the subsequent period in feedlot, when the implanted and control groups were implanted at the beginning of the feedlot phase and received the same fattening ration. Similar results were observed by Mader et al. (1983), who concluded that implants during the sucking period may not be necessary.

Little information is available on the effects of zeranol on skeletal growth. In a study in which hip heights of steers implanted from birth to slaughter were compared to hip heights of bulls implanted from birth to slaughter, non-implanted bulls, bulls implanted from birth to weaning, and bulls implanted from weaning to slaughter, Unruh et al. (1983) observed that steers implanted from birth to slaughter were shorter than all other groups. Non-implanted bulls and bulls implanted from birth to weaning were taller than the other groups. These results suggest that zeranol tended to reduce skeletal growth. This assumption is supported by results from Staigmiller et al. (1983), who reported two trials with heifers. In the first trial, no difference was observed in hip heights between the implanted and control groups. In the second trial, however, significantly smaller values for hip height were observed in implanted heifers, when height was adjusted for body weight.

Zeranol has been shown to effect pelvic area of heifers. Larger pelvic areas in yearling heifers implanted at weaning were reported by Corah (1980). Similarly, Ellington et al. (1978) observed a larger average pelvic area at weaning in heifers that had been implanted during the suckling period. Also, Staigmiller et al. (1983) observed that heifers implanted with zeranol at the age of 9 to 11 months had a larger pelvic area at the beginning of the breeding season and at palpation for pregnancy. However, conflicting results were reported by Anthony et al. (1981). In the first trial, the heifers were implanted at 100 days of pregnancy and implants resulted in an increase in pelvic area, which was evident in measurements taken in each of the 3 months following implantation, but a difference was not observed by the fifth month postimplant (1 month before calving). In the second trial, successive implants during pregnancy did not cause any increase in pelvic area.

Negative effects of zeranol on the reproductive performance of females of different species have been reported. A pseudopregnant state was observed in gilts when zeranol was implanted at puberty (Etienne and Jammali, 1982). When gilts were fed postmating on diets containing high levels of zeranol, no development of embryos or absorption of embryos was observed (Long and Diekman, 1984). Also, zeranol implanted in ewe lambs decreased ovary weight and reduced ovulation rate (Cooper, 1982). Experimental results with heifers suggest that the effect of zeranol implants on reproductive performance may be influenced by age of the heifer at the time of implantation, by the number of reimplants, and by the dosage used. Nelson et al. (1972) utilized 293 Hereford heifers, averaging 200 kg liveweight, to study the effect of 36 and 72 mg zeranol implants on future conception rate. The heavier one-half of the heifers was selected for breeding 196 days after implantation. The authors concluded that both levels of zeranol significantly depressed conception rate. Staigmiller et al. (1983) studied the effects of zeranol implants on pregnancy rate of Hereford and Angus heifers in two different trials. The heifers were implanted at an age of 8 to 11 months. They did not find any difference between the treated and untreated groups in age or weight at onset of puberty. Pregnancy rate tended to be lower (62 vs. 78%) for implanted heifers in the first trial but no difference was observed in the second trial (88 vs. 87%). No depressive effect on fertility was observed by Corah (1980), when suckling heifers were implanted with 36 mg of zeranol. He also reported that when 36 mg of zeranol were implanted in heifers postweaning, it caused a depression in fertility, but no adverse effect was observed when zeranol was implanted at levels of 12 or 24 mg. Anthony et al. (1981) observed a higher incidence of abortion when zeranol was implanted in heifers one or three times during pregnancy.

According to Johnson (1984), it may not be realistic to try to explain the mode of action of a growth promotant due to the complex interrelationships involved, but he suggested that the effect of zeranol appeared to be coupled to its ability to mimic many biological and molecular effects of estrogen. Decreases in FSH and LH levels in response to zeranol implant have been reported in sheep (Riesen et al., 1977; Cooper, 1982, Elsasser et al., 1982). Reduction in the levels of these gonadotropins could explain the reduction in levels of gonadal hormones that have been reported (Anthony et al., 1981; Berger et al., 1981; Johnson, 1984; Staigmiller et al., 1985), and bring the depressive effects in the reproductive performance of males and females. Zeranol, on the other hand, causes increases in the levels of growth hormone and prolactin, and these two hormones could mediate at least part of zeranol's anabolic effect, as suggested by Johnson (1984), who also admitted that zeranol may also have a direct anabolic effect, binding to estrogen receptors in the cells.

Treatment Effects on Maternal Ability

Creep Feeding

Creep feeding heifers, as well as providing them supplemental feed postweaning, is known to have positive immediate effects on weight gains, and due to the close relationship existing between live weight and the onset of puberty, normally increases the percentage of heifers cycling at the beginning of the breeding season. However, permanent detrimental effects of overfeeding heifers in some periods of their lives on future maternal ability, expressed in terms of weights of their calves at different ages and milk production, have been observed. The depressive effects of overfeeding on maternal ability have been shown to be more consistent and more pronounced than the reported negative effects on reproduction.

Swanson (1960), working with identical twin heifers with initial ages varying from 4 to 12 months, fed one heifer of each pair a normal ration while its mate was fed to produce rapid gain and fattening until calving. The overfed heifers produced significantly less milk than the controls and had a lack of development of secretory tissue in some areas of the mammary gland. In agreement with these results, many authors, among them Hanson (1956), Sejrsen (1978), Little and Kay (1979), and Sejrsen et al. (1982), showed depressive effects of overfeeding on milk production. However, Reid et al. (1963) did not find a difference in milk production between heifers fed three levels of energy, corresponding respectively to 62%, 100%, and 146% of the recommended standard (Morrison, 1956) from birth to calving.

Sejrsen (1978), in a review, suggested that there is a critical period in which high energy intake has a greater depressive effect on future maternal ability of heifers. He proposed that the critical period would correspond to the phase of allometric growth of the mammary gland (period in which the mammary gland grows at a faster rate than the liveweight), which is from 3 to 6 months of age to 2 to 3 months after puberty. Results from Little and Kay (1979) support the assumption that early life might be a critical period. They fed dairy heifers to gain either .7 kg or above 1 kg per day from about 3 to 9 months of age. Heifers with gains restricted to 7 kg produced, in each of three lactations studied, more than 1000 kg of milk above those fed to gain more than 1 kg per day. In agreement with the above results, Halloway and Totusek (1973b) showed that creep-fed heifers tended to produce less milk as cows than those that were not creep-fed. Similarly, studying the effect of creep feeding on Angus and Hereford heifers, Hixon et al. (1982) measured milk production at 60 and 120 days of lactation and concluded that creep feeding significantly reduced milk production.

Sejrsen et al. (1982) conducted an experiment to test the hypothesis that high gains during early life would depress milk production and that overfeeding after puberty would not have a depressive effect. They compared the effect of overfeeding pre- and postpubertal heifers on the development of ductular epithilial tissue of the mammary gland. Prepubertal heifers were 7 months old at the beginning of the experiment, while postpubertal heifers were 13 months old and were cycling regularly at beginning of the experiment. They concluded that a high plan of nutrition before and around puberty had a depressive effect on mammary development but had no effect on postpubertal heifers. Reduction in mammary development as a consequence of high nutritional level was also observed by Pritchard et al. (1972) and Amir, cited by Sejrsen (1978).

There is no general consensus about the way overfeeding may depress future milk production. Swanson (1960) explained the depressive effect as a direct effect of fattening and Martin et al. (1981) suggested that increased fat deposition in the udder might hinder secretory tissue development with a consequent permanent reduction in milk production. Little and Kay (1979) stated that the mechanism by which fattening affected subsequent milk production was unknown. Sejrsen (1978), in a review, found evidence that high energy levels in the diet depress the levels of growth hormone and prolaction in the blood. Since these two hormones are of fundamental importance for the development of the secretory tissue, he concluded this could be the way overfeeding depresses mammary development and milk production. However, Tucker (1981) affirmed that the hormonal implications between energy intake and mammary development still need to be established.

Many authors have observed a high correlation between milk production of the dam and weight of the calf at different ages during the suckling period (Neville, 1962, Rutledge et al., 1971, Reynolds et al., 1978, Hixon et al., 1982). In agreement with these results, several studies showed that the depressive effect of overfeeding early in life on future milk production resulted in cows producing lighter weight calves. Holloway and Totusek (1973b) reported that birth weights of calves from creep-fed cows were higher than those from noncreep-fed cows, but that creep-fed cows tended to wean lighter weight calves in each of three calf crops studied and the calves had lower condition scores at weaning. Similar results were obtained by Martin et al. (1981), who showed that calves from creep-fed cows were lighter at 120 and 210 days of age. In addition, creep-fed cows weaned significantly less kilograms of calf during their lifetime. Finney et al. (1972) also observed that cows receiving supplemental feed levels above the levels recommended by NRC weaned less pounds of calf during their lifetime.

Some reports suggest that, even under normal management of farms, the weight gain of replacement heifers may exceed a hypothetical threshold, above which future maternal ability would be depressed.

Johnson and Obst, cited by Johnson and Morant (1984), reported that higher milk yields and higher weight gains of calves were obtained at first calving from Hereford heifers that had restricted growth to 8 months of age. The restricted-growth heifers continued weaning heavier calves in three subsequent calf crops (+41, +27, and +26 kg, respectively). Also, Mangus and Brinks (1971) reported a detrimental effect of high levels of nutrition during the preweaning period on subsequent productivity of beef heifers. They also reported that, over four generations, there was a cyclic effect with good mothers producing poor mothers and vice-versa. An additional negative effect that has been observed as a consequence of over-feeding during early life is a reduction in the cow's life span (Pinney et al., 1972; Martin et al., 1981).

Several authors have presented upper limits for daily gain, above which future production of dairy heifers would be depressed. The upper limits vary in the range of 500-800 g and are influenced by the mature size of the breed (Swanson, 1960, Amir cited by Sejrsen, 1978, Sejrsen, 1978). In a study with beef and dual purpose breeds including Angus, Hereford, Charolais, Red Poll, Brown Swiss, and Simmental, Ferrell (1982) concluded that heifers gaining .6 kg daily, during a 184-day postweaning period, produced more milk and had heavier calves at 120 days postcalving than those gaining either .4 or .8 kg daily.

Zeranol

Very little information exists on the effect of zeranol implants on future maternal ability of heifers. Anthony et al. (1981) reported results of two trials in which zeranol was implanted one or three times in pregnant heifers. Zeranol implant did not affect calf birth weight or calf weaning weight in the first experiment, but did increase calving difficulty. In the second experiment, zeranol tended to reduce calf birth weight and to increase calving ease, but increased incidence of abortion. No information about calf weaning weight was given for the second experiment.

Corah (1980) reported that zeranol implants had no depressive effect on milk production and, Morrison et al., cited by Johnson (1984), observed that heifers implanted with zeranol at weaning produced significantly more milk and weaned heavier calves than controls.

Other Factors

Genotype of the dam is the most important factor affecting the weaning weight of the calf, since it partially determines the genotype of the calf and, especially, because it determines the milking ability of the dam.

The close relationship between milk production of the dam and calf weaning weight has increased interest in crossbreeding between dairy and beef breeds as a way to produce cows with higher milking ability. However, cows that produce more milk may not be the most economical, because of their higher nutritional requirements and the negative relationship that may exist between level of milk production and reproductive rate. According to William (1972), for a given TDN availability, increases in milk production can not exceed that level which leaves enough nutrients for successful rebreeding. This statement was supported by Franke (1977). He compared straightbred Angus and Hereford cows to F_1 cows from Angus and Hereford dams and sired by Angus, Hereford, Charolais, Brown Swiss, and Holstein bulls Calves from dairy-beef crossbred cows were heavier at weaning than those from straightbred and beef-beef crossbred cows, however, calving rates were lower for dairy-beef crossbred cows. The author concluded that reproduction in dairy-beef females, under semi-improved pasture conditions, may not permit economical calf production. Olson (1980) and Euclides et al. (1983), reporting results from the same population of animals, compared the efficiency of Brown Swiss, F_1 Brown Swiss-Angus, and Angus cows. Cows and calves were maintained in pens and cow-calf feed consumption was recorded. Brown Swiss cows weaned the heaviest calves and Angus cows the lightest Cow productivity, expressed in terms of kilogram of calf weaned per kilogram of cow, favored Brown Swiss and F_1 cows. However, when results were expressed in terms of kilograms of TDN consumed by the cow-calf pair per kilogram of calf weaned, results were highly favorable to Angus cows. The F_1 cows were more efficient than Brown Swiss cows, but did not attain the level of the Angus cows

Breed of sire is known to affect calf weaning weight through its direct effect on the genetic potential of the calf for growth In addition, some studies have indicated that milk production of the dam may be affected by the genotype of the calf (Cartwright and Carpenter, 1961, Reynolds et al., 1978). One way crossbred calves might stimulate milk production of the dam would be through a greater challenge resulting from higher nursing frequency, as reported by Cartwright and Carpenter (1961). A hormonal influence of the genotype of the calf on milk production of the dam was suggested by Tucker (1980), who stated that sire of calf affected subsequent lactation of the dam presumably as a result of different levels of placental lactogens secreted by the fetal placenta, which is genetically derived half from the bull and half from the cow. Effects of the fetal-placental unit on postpartum performance of dairy cows were quantified by Thatcher et al. (1979). They concluded that sire of fetus accounted for 8.2 and 11.8% of the variability in mature equivalent milk yield in Holstein and Jersey cows, respectively.

Age of cow is another important factor which has been shown to affect maternal performance, irrespective of breed, location, nutritional level, and other particular characteristics of different experiments. Lawlor et al. (1984) divided cows into three categories of 3, 4, and more than 4 years of age. As age of cow increased, there was an increase in calf weaning weight, weaning height, and condition score. Nelson et al. (1982) observed that calf weight gain, during the preweaning period, improved as age of cow increased from 2 to 4 years, but that no additional increase in calf weight gain occurred as cow age increased in the range of 4 to 7 years. These results are supported by Gaskins and Anderson (1980), who observed a positive linear trend (b = 1 kg per year) in daily milk production as cow age increased from 2 to 4 years, and Melton et al. (1967), who observed an increase in milk production up to 5 years of age. An additional positive effect that has been observed as cow age increases is a reduction in the incidence of dystocia, which may result in increased calf survival (Nelson and Beavers, 1982, Lawlor et al., 1984).

Another factor that some studies have shown to have a small effect on maternal ability is the sex of calf. Dickey et al. (1970) used the calf-weight-change method to estimate milk production, and observed that bull calves consumed an average .28 kg more milk than heifers. Conflicting results were reported by Jeffery et al. (1971), in a 2-year study. In the first year, cows nursing male calves produced .26 kg more milk per day, but, in the second year, they observed an advantage for cows nursing heifer calves.

Estimation of Milk Production in Beef Cows

Comparison of Methods

The technique used for estimating yield and composition of milk from beef cows must provide accurate and repeatable information and should be simple enough to permit a relatively large number of animals to be handled without undue stress (Le Du et al., 1978). Many different methods have been used and some modifications of old methods have been made in the search for a procedure which would combine all those desirable characteristics. Methods used include calf-weight-change method (Drewry et al., 1959, Totusek et al., 1973, Neidhardt et al., 1979; Gaskins and Anderson, 1980), hand milking and machine milking, preceded or not by the injection of oxytocin (Anthony et al., 1959; Gleddie and Berg, 1968, Somerville and Lowman, 1980; Chenette et al., 1982), machine milking after injection of tranquilizer and oxytocin (Belcher and Frahm, 1979, Martin and Franke, 1982), and indirectly by weighing the calf at weaning.

One of the most widely used methods is the calf-weight-change method. By this method, calves are separated from their dams during a pretest period of about 6 to 8 hours. At the end of this period, the calves are allowed to suckle their dams to remove, as well as possible, all the milk from the mammary glands. This marks the beginning of the test period, normally a 12-hour period, in which the calves stay separated from their dams. At the end of the test period, calves are weighed, allowed to suckle and weighed again. Milk production is estimated as the difference between the weights of the calves, after and before suckling. The production is then adjusted to a 12- or 24-hour period, considering milk secretion rate to be constant.

Totusek et al. (1973) compared the calf-weight-change method with hand milking and concluded that the calf-weight-change method gave an estimation 29% higher than hand milking. However, no exogenous oxytocin was used to help milk letdown when cows were milked by hand. Milk was removed by hand from two teats of a side of the udder, while the calf suckled the teats on the other side, and the estimation by calf-weight-change method was based on measurements made in different days from hand milking. Higher values for milk production obtained by calf-weight-change method, in comparison to hand milking, were also observed by Neidhardt et al. (1979), in Brahman cattle. Twenty IU of oxytocin were injected before hand milking, but they reported that a single injection was not enough to permit a complete milk removal and a second 10-IU injection was applied when the action of the first injection ceased to permit complete milking.

Machine milking has been compared to the calf-weight-change technique. Somerville and Lowman (1980) compared the calf-weight-change method to machine milking in a study with Hereford-British Friesian cows. They concluded that machine milking without exogenous oxytocin increased the number of animals drying-off within 150 days of parturition. On the other hand, Wistrand and Riggs (1966) compared calf-weight-change milking with oxytocin-aided machine milking of Santa Gertrudis cows and did not find a difference in yields estimated by the two methods. A higher efficiency of oxytocin-aided machine milking, in comparison to the calf-weight-change method, was observed by Belcher et al. (1978), in a study involving Angus and Hereford straightbred cows and crossbred cows from Angus and Hereford cows and sired by Simmental, Brown Swiss, and Jersey bulls. The difference in favor of machine milking was more evident in crossbred animals. Gleddie and Berg (1968) used machine milking to estimate milk yield at four different phases of the lactation period. At day 30 of lactation, the calf-weight-change method was also used and it gave a lower estimate for milk production than did machine milking.

Lamond et al. (1969) used a milk catheter after injection of oxytocin in Hereford cows. They reported that the milk catheter permitted milk removal in 2 to 4 minutes and, despite the catheter caused bleeding in some cows, this apparently did not result in higher incidence of mastitis. They concluded that the method could have a wide application in studies with beef cows.

Much controversy exists about which would be the most efficient method. Totusek et al. (1973) and Neidhardt et al. (1979) considered the calf-weight-change method to be the most appropriate for beef cows because, according to them, it causes less stress to cows not used to being milked. This is not, however, in agreement with Reynolds et al. (1967), who concluded that some measurements taken in Brahman cows using the calf-weight-change method were probably inaccurate because of the temperament of some cows and because some calves failed to nurse. Le Du et al. (1978) and Somerville and Lowman (1980) pointed out that the calf-weight-change method is more laborious and does not permit a representative milk sample to be taken. Other disadvantages that have been attributed to this method are that as the calves get older it is more difficult to measure accurately changes in their weight (Le Du et al., 1978) and, if the calf urinates or defecates, this results in underestimation of milk production (Yates et al., 1971). However, according to Neidhardt et al. (1979), adjustment for this last source of error can be made. Another fact that has been observed is that the calf-weight-change method tends to underestimate milk production during early lactation (Gleddie and Berg, 1968; Totusek et al., 1973, Neidhardt et al., 1979).

Machine milking, hand milking, and the milk catheter have the common disadvantage of not permitting estimation of milk consumed by the calves, and injection of oxytocin required for milk letdown may result in removal of more residual milk and this might affect milk yield and composition.

In general, the differences observed in milk yield when different methods are compared are not large and, even when results are significantly different, authors have shown that the correlation between values from different methods tend to be high. Totusek et al (1973) found correlations of .92, .92, and .95 between milk yields estimated from hand milking and the calf-weight-change method, at 70, 112, and 120 days of lactation, respectively. Chow et al (1967) reported a correlation of .83 between yields obtained by machine milking and the calf-weight-change method, and Belcher et al. (1978) found a correlation of .79.

Experimental results suggest that, for purposes of ranking treatments, different methods could be equally efficient, even when estimates of total yields differ.

Effect of Sampling Frequency

Milk production in beef cattle has been determined usually by sampling production at prefixed dates (Schwulst et al., 1966; Melton et al., 1967, Gaskins and Anderson, 1980). Irrespective of the method used, measuring milk yield in beef cows is time and labor consuming and is stressful for cows and calves. This has motivated research to determine which sampling interval would provide the best estimation of actual production with a minimum of disturbance for the herd.

Neville (1962) milked cows four times during lactation and calculated the correlation between milk production and calf weight gain. He concluded that only two or three milk samplings during a lactation are needed to determine the relationship between milk yield and calf gain. Rutledge et al. (1972) measured milk production seven times during the lactation to determine combinations of three samples which would predict well the total milk obtained from the seven samplings. Equations based on samplings made during the first, third and fifth or the second, fourth and sixth months of lactation were developed. They tested the equations in two independent data sets and found correlations above .93 between predicted and observed values. Similarly, Totusek et al. (1973) found correlations of .99 and .94, respectively, between actual 210-day production and estimates of 210-day production based on weekly and monthly sampling. For selected-day samples (day 30, 70, 112, and 210 of lactation) the correlation improved as the number of days increased from 1 to 4 (.48, .77, .85, and .91). Addition of other days did not increase the correlation.

Effects of Sampling Time, Secretion Period, and Pretest Period Length

When measuring milk yield of beef cows, researchers have usually sampled milk one time a day and sometimes twice a day. The secretion period preceding milking varied in length, but commonly a 12-hour period has been used (Wistrand and Riggs, 1966, Melton et al., 1967, Totusek et al., 1973, Gaskins and Anderson, 1980, Chenette et al., 1982). However, periods of about 14 to 16 hours have also been used (Reynolds et al., 1967, Dickey et al., 1970, Reynolds et al., 1978), and some authors have measured milk after a 4- to 6-hour secretion period (Schwulst et al., 1966, Le Du et al., 1978, Neidhardt et al., 1979, Franke and Martin, 1983).

The effect of the length of secretion period on milk yield has been studied mostly in dairy cows. Schmidt (1960) compared the effects of secretion periods 4, 8, 12, 16, and 20 hours long. They concluded that periods longer than 12 hours caused a decrease in milk production, but no difference existed among periods equal or shorter than 12 hours. Similarly, Elliot (1959) stated in a review that for practical purposes milk secretion is unaffected by intervals up to 12 hours. Chenette and Frahm (1981), working with F_1 cows from Angus and Hereford dams and sired by dairy bulls, reported that a secretion period of 9 hours gave a higher estimate of milk production than secretion periods of 6 or 12 hours. Chow et al (1967) compared the effects of milking intervals varying from 4 to 24 hours in Hereford cows and concluded that 2, 12-hour intervals were adequate for effectively measuring milk yield, either by the calf-weight-change method or by machine milking.

Effects of time of day samples are taken have also been considered in some studies. Gilbert et al. (1973) demonstrated that yields of milk, fat, and protein and percentages of fat and protein were not equal in samples taken in the morning and in the afternoon, even though successive milking intervals of 12 hours were used in a 15-day milking study. Milk yield was .65 kg greater in the morning than in the evening milking and percentages of fat were 3.92 and 4.24 for a.m. and p.m. sampling, respectively. For dairy cattle, different factors have been proposed for the adjustment of a single a.m. or p.m. milk record to a 24-hour basis, when the secretion period is the same (Hargrove and Gilbert, 1984, Lee and Wardrop, 1984).

Research has shown that milk composition may be affected by the length of the test period itself and by the length of the period which precedes the test period Higher fat percent in milk was observed when cows were milked after a short secretion period. Elliot (1959) reported that fat percentage was 8%, after a 1-hour, and 4% after a

14-hour interval. Similarly, Ormiston et al. (1967) found 3.56% fat in milk when the secretion period was 14.5 hours and 4.07% for a secretion period of 9.5 hours. These results were supported by results from Chenette and Frahm (1981).

A carryover effect of a long secretion period on milk yield and composition in the following period has been observed. Le Du et al. (1978) reported that an extended period before 4- and 6-hour measurement periods caused an underestimation of milk production and an overestimation of fat yield. An increase in milk fat percentage when a short interval followed a long interval was also reported by Elliot (1959). He explained that a long secretion period caused greater retention of residual fat, which remained even after an injection of oxytocin, and increased the fat content in the subsequent milking. These results were supported by Schmidt (1960), who also concluded that long intervals preceding a 12-hour milk secretion period caused a depression in secretion rate and a marked increase in milk fat percentage.

The use of oxytocin may also affect milk yield and composition. According to Tucker (1980) approximately 15 to 25% of the total amount of milk in the udder at the start of milking is not removed during milking. Part of this milk may be removed when oxytocin is injected in the cow. The residual milk is much richer in fat than the average milk removed, thus, removal of this milk could increase fat content. He also stated that the first milk removed from the udder contains as low as 1 to 2% of milk fat, while the last milk removed may contain 7 to 9% of fat.

Yield and Composition of Milk from Beef Cows

Daily milk yield and milk composition reported for beef cows vary widely as a consequence of differences in breed, level of selection of different herds, nutrition, method of sampling used, etc.

Values of milk yield reported for Hereford cows are, in general, lower than for other beef breeds (Melton et al., 1967, Dickey et al., 1970, Chenette et al., 1982, Franke and Martin, 1983), and average daily values reported for this breed varied in the range of 3.7 to 6.0 kg. However, an extreme value of 8.1 kg was reported for Herefords by Kress et al. (1984). Angus cows have been shown to produce more milk than Hereford cows, but when compared to other breeds, like Brahman, Charolais, and Brangus, lower values have been observed for Angus (Franke and Martin, 1983, Melton et al., 1967, Reynolds et al., 1978). Daily yields for Angus normally varied from 4.8 to 6.6 kg, while for Brahman, Franke and Martin (1983) and Neidhardt et al. (1979), respectively, reported average values of 6.4 and 6.2 kg per day. In general, authors agree that crossbred cows produce more milk than the average of the parent breeds, and among the crossbred animals higher values have been observed for dairy-beef crosses. Euclides et al. (1983) reported an average production of 6.8 kg of milk for reciprocal F_1 Angus-Brown Swiss crossbred cows. Isea (1985) pooled data for reciprocal F_1 and F_2 Angus-Brown Swiss crossbred cows, from inter se mating of F_1 animals, and reported an average daily milk yield of 8.4 kg. Average milk yields of 5.8, 7.7, and 7.7 kg were reported by Gaskins and Anderson (1980) for Angus-Hereford, Jersey-Angus, and Simmental-Angus cows, respectively. Results from Franke and Martin (1983), for straightbred cows and 2-, 3-, and 4-breed rotational crossbred cows, involving the Angus, Brahman, Charolais, and Hereford breeds, were 5.04, 7.09, and 6 60 kg for straightbred, 2-breed rotation crossbred, and pooled 3- and 4-breed rotational crossbred cows, respectively.

Values for protein content of milk from beef cows generally vary from 3.0 to 3.3% (Schwulst et al., 1966, Chanette at al., 1982, Franke and Martin, 1983), but a high value of 3.76% was observed by Rutledge et al. (1971).

Some authors have found relatively low percentages of fat in milk of beef cows, in the range of 3.6 to 4.2% (Schwulst et al., 1966, Rutledge et al., 1971, Belcher and Frahm, 1979). However, in more recent work, values from 4.59 to 5.2% have been reported (Franke and Martin, 1983, Chenette and Frahm, 1981, Chenette et al., 1982).

Total solids content of milk is closely related to milk fat content. Percentages of total solids in milk of beef cows vary from 12.85 to 14.34% (Gleddie and Berg, 1968, Franke and Martin, 1983, Chenette and Frahm, 1981, Chenetta et al., 1982)

Shape of Lactation Curve of Beef Cows

There is little information about the shape of the lactation curve of beef cows. Often, times and frequency of sampling do not permit the determination of a possible peak of lactation. In other cases, when the calf-weight-change method is used, authors suggest that the peak, sometimes observed, might be influenced by the inability of young calves to consume all the milk produced by their dams Some authors indicate the existence of a lactation peak in beef cows similar to that in dairy cows Studies of physiology of the mammary gland, which show that mammary development continues for some time following parturition in some species including the cow (Ceriani, 1974; Tucker, 1980), support the existence of a lactation peak.

Totusek et al. (1973) found a peak in milk yield at about 3 weeks of lactation, when production was determined weekly by hand milking, and at 7 weeks of lactation when milk yield was determined by calf-weight-change method. Chenette and Frahm (1981) worked with Angus and Hereford straightbred cows and F_1 cows from Angus and Hereford dams and sired by Hereford, Angus, Brown Swiss, Simmental, and Jersey bulls. Cows were milked by machine after injection of a tranquilizer and oxytocin. The authors concluded that production increased from first milking, at about day 30 of lactation to the second milking at about day 60 of lactation. A peak at 30 days of lactation in Brahman cows was reported by Neidhardt et al. (1979) and a similar peak was observed in Hereford-British Friesian cows by Somerville and Lowman (1980), when milk yield was determined either by machine milking or by the calf-weight-change method. Some authors, however, did not observe a peak in the lactation curve. Working with Hereford cows, Rutledge et al. (1971) observed the same levels of production at days 30 and 60 of lactation, and a continuous decrease in milk yield in samples taken after day 60 of lactation. Gleddie and Berg (1968), working with six different breed-age groups of beef cows, observed that milk yield, obtained by machine milking, tended to peak for three groups at approximately 60 days of lactation and for the other three groups production dropped linearly from the first to fifth month of lactation. Continuous decreases in milk yield after the first milking at approximately day 30 of lactation were reported by Robison et al. (1978) and Gaskins and Anderson (1980).

Correlation Between Milk Yield and Calf Growth

Some authors have calculated the correlation between milk yield and calf weight and calf weight gain. Relatively low correlation values were observed by Chenette and Frahm (1981) in a study with crossbred dairy-beef cows. The values observed were .20 for the correlation between milk yield and calf weaning weight and .29 between milk yield and calf gain from birth to weaning. Many values reported for correlations between milk yield and calf weight and calf weight gain were, however, higher. Values varying from .42 to .68 were observed by Wistrand and Riggs (1966), Gleddie and Berg (1968), Dickey et al. (1970), Reynolds et al. (1978), and Robison et al. (1978). Very high values of .75 and .83 for the correlation between milk yield and calf weight gain were observed when calves were maintained with their dams in dry lot under controlled feed intake (Neville, 1962, Totusek et al., 1973).

STUDY 1
POSTWEANING GROWTH AND REPRODUCTION

Introduction

Creep feeding has been shown to increase calf weaning weight (Furr and Nelson, 1959, Burns and Koger, 1963, Holloway and Totusek, 1973a, Martin et al., 1981, Prichard, 1983). This practice has been considered profitable by some authors (Wilson et al., 1966, Hunsley et al., 1967) and unprofitable by others (Nelson et al., 1953, Furr and Nelson, 1959, Temple and Robertson, 1961, Preston and Willis, 1974).

Zeranol implantation is considered to be a profitable way to increase weight gain of heifers and steers during the preweaning period, as well as in other phases of growth (Corah, 1980, Prichard, 1983, Simms, 1983, Steigmiller et al., 1985).

Growing heifers at faster rates decreases age at puberty, since there is a close relationship between live weight and onset of puberty (Hanson, 1956, Crichton et al., 1960, Cohen et al., 1980, Wiltbank, 1983). Management practices that promote prepubertal growth would, therefore, increase the percentage of heifers cycling at the beginning of the breeding season, with beneficial effects on pregnancy rate (Ferrell, 1982, Wiltbank, 1983). These results suggest that creep feeding and zeranol, through their effects on weight gain, could increase the proportion of heifers cycling at the beginning of the breeding season, thus increasing pregnancy rate. However, studies have shown that postweaning zeranol implants had a detrimental effect on reproduction (Nelson et al., 1972, Corah, 1980) Corah (1980) did not show any negative effects of preweaning zeranol implants on reproduction. Some depressive effect of creep feeding on future reproduction was observed by Martin et al. (1981). Etienne and Martin (1979) concluded that the heaviest heifers at weaning had poorer reproductive performance than medium weight heifers, in a study in which part of the heifers had been creep-fed. On the other hand, no depressive effect of creep feeding on reproduction was observed by Holloway and Totusek (1973b), Little and Kay (1979), and Hixon et al. (1982).

Creep-fed heifers have been used for reproduction, and nursing calves often are implanted with zeranol before selection of replacement heifers is made. This study was conducted to evaluate the combined effects of zeranol and creep feeding on postweaning development and reproduction of crossbred heifers.

Experimental Procedure

This project was conducted at the Beef Research Unit of the University of Florida, located 12 miles north of Gainesville. The climate is classified as semitropical, with no defined dry season. Forty-four heifers born in 1981 and 48 heifers born in 1982 were used in this study. The heifers were from Angus and Angus-Brown Swiss F_1 cows and sired by Brahman and Romana Red bulls. About one-half of the heifers were implanted with 36 mg of zeranol at an average age of 56 days and reimplanted 90 days later. Creep feeding treatments included no creep, creep feeding from about 146 days of age to weaning at 210 days of age (short term), and creep feeding from about 56 days of age to weaning (long term). The number of heifers for each breed of sire, breed of dam, creep feeding, and zeranol combination is shown in table 1. Details on the management of the animals during preweaning period were reported by Prichard (1983).

After weaning in September the heifers were maintained on pasture consisting mainly of bahiagrass (*Paspalum notatum* Flugge) and white clover (*Trifolium repens*) and received 2.3 kg per head per day of a concentrate mixture consisting of 80% high moisture corn (IFN 4-20-770) and 20% cottonseed meal (IFN 5-01-617). As the quality of the pasture declined in late fall, corn silage (IFN 3-20-506) was fed, in addition to the concentrate mixture. Corn silage was fed initially at a level of 7 kg per head per day and, as the quality of the pastures decreased, the daily amount fed was increased to 10 kg per head. This diet was maintained until April, which was the beginning of the breeding season.

Ovarian structures and status of the reproductive tract of yearling heifers were determined by rectal palpation at the beginning of the breeding season. At this time, height and width measurements of the pelvic opening were obtained as described by Bellows et al. (1971) and used to calculate pelvic area. All females were exposed in multi-sire herds to Polled Hereford and Hereford bulls for a 60-day breeding season. They were weighed and scored for body condition at the beginning of the breeding season and at weaning time. At this time, hip height was measured on all breeding females, they were palpated for pregnancy, and all open females were culled.

Winter supplementation was started in November. Pregnant animals were fed corn silage, molasses and cottonseed meal. Corn silage was

TABLE 1. NUMBER OF HEIFERS BY BREED OF SIRE, BREED OF DAM, CREEP FEEDING, AND ZERANOL TREATMENTS

Breed of sire	Creep feeding	Breed of dam			
		Angus		F_1 Brown Swiss-Angus	
		Zeranol	No Zeranol	Zeranol	No Zeranol
Brahman	No creep	4	4	6	3
	Short-term	5	4	4	6
	Long-term	3	4	4	6
Romana Red	No creep	4	2	3	4
	Short-term	3	2	4	3
	Long-term	3	2	4	5

fed three times per week to provide an initial average daily intake of 11 kg per head, and as the quality of the pastures decreased the quantity fed was increased to approximately 20 kg per head for pregnant yearling heifers and 27 kg for 2- and 3-year-old cows. Molasses was fed with the corn silage to provide a daily intake of 2.3 kg per head and cottonseed meal was fed to obtain daily intakes of 3 and .7 kg per head for yearling heifers and cows, respectively. Two-year-old lactating cows were fed silage ad libitum and a daily equivalent of 2.3 kg of high moisture corn, 2.3 kg of molasses and .45 kg of cottonseed meal from calving until mid-March. The 3-year-old lactating cows were maintained on pasture after calving and received approximately 27 kg of corn silage and .7 kg of cottonseed meal per head per day until adequate pasture forage was available, about March 15. A complete mineral supplement was available to all animals.

Data were analyzed using the General Linear Model (GLM) procedures of the Statistical Analysis System (SAS), version 1982.

Traits considered included pelvic area and cycling status of yearling heifers at the beginning of the breeding season, pelvic area, and weight just prior to calving as 2-year-olds, weight and condition score at beginning of each breeding season, weight, condition score, hip height, and pregnancy status on the day calves were weaned and weight at about days 30, 70, 120, and 190 of each lactation.

All traits were analyzed by the method of ordinary least squares analysis of variance. Various mathematical models were used, but a similar sequence was followed in all analyses. In analyses that did not involve repeated measurements on a same animal, i.e., cycling status, pelvic area at the beginning of first breeding season, pelvic area, and weight prior to first parturition, weights, heights and condition scores at specific ages, and pregnancy rate at first breeding, the models used included the fixed effects of treatments, interactions among treatments, and year.

As the first step in each analysis, the complete model used contained the fixed effects of mean, year, creep feeding, zeranol, breed of sire, breed of dam, and all 2-, 3-, and 4-factor interactions. In the analyses of live weight, pelvic area and cycling status at the beginning of the first breeding season, age in days of the heifer was included as a covariate and, in the analysis of pelvic area just prior to first calving, interval in days from date of measurement to calving was included as a covariate.

After the first run, nonsignificant interactions that were not involved in significant higher order interactions were dropped from the model and the reduced model was used to obtain least squares estimates for main effects and significant interactions

In analyses of traits involving repeated measurements on the same animal, i.e., rebreeding in successive breeding seasons, the random effect of cow nested within creep feeding, breed of sire, and breed of dam was included. This random effect was used as the error term to test main effects of treatments and interactions among treatments. The F test was performed using the type II sums of squares, and appropriate standard errors of means were calculated on the basis of the components of variance of the means After the first run, cow and all nonsignificant interactions that were not contained in higher order interactions were dropped from the model and new analyses were performed to obtain the least squares estimates.

Partial correlations, adjusted for treatment effects and for the effects of all possible interactions among treatments, were estimated to study the relationships between cycling status and yearling pregnancy rate, weight and pelvic area at the beginning of the first breeding season, weight and pelvic area just prior to first calving, height at palpation for first pregnancy and pelvic area at the beginning of first breeding season, and hip height at palpation for first pregnancy and pelvic area just prior to first calving.

Results and Discussion

Weight Changes

The least squares estimates and standard errors for weights of animals of the different treatment groups, from the beginning of the first breeding season as yearlings to palpation for the third pregnancy, are shown in tables 2 and 3.

Prichard (1983), working with the same animals until weaning, found that creep-fed heifers were significantly heavier at weaning than noncreep-fed heifers, and that no significant weight difference existed between the two creep-fed groups. In the present study the weight difference in favor of creep-fed animals was still present ($P < .05$) at palpation for third pregnancy (tables 2 and 3). Most data reported on creep feeding show that differences in favor of creep-fed animals do not persist as long as was observed in this study. Burns and Koger (1963) reported that the difference in favor of creep-fed heifers was erased when the heifers were 18 months old,

TABLE 2. LEAST SQUARES ESTIMATES ± SE FOR WEIGHT OF THE COWS AT DIFFERENT STAGES OF DEVELOPMENT

	Weight, kg					
Source of variation[a]	Start of first breeding season	End of first breeding season	Palpation for first pregnancy	Start of second breeding season	End of second breeding season	Palpation for second pregnancy
Creep treatment[b]						
No creep (NC)	310.3 ± 6.6	326.3 ± 3.8	363.3 ± 8.8	301.1 ± 3.6	356.6 ± 8.6	393.3 ± 1.8
Short term (SC)	320.8 ± 5.5	343.6 ± 3.6	381.6 ± 3.3	398.0 ± 8.8	393.6 ± 8.3	429.2 ± 8.6
Long term (LC)	323.2 ± 3.1	341.3 ± 3.3	381.6 ± 3.6	318.5 ± 3.6	317.3 ± 6.3	320.3 ± 1.3
Zeranol treatment						
No zeranol	306.1 ± 8.8**	330.3 ± 4.8*	316.3 ± 3.6+	373.3 ± 6.8	373.3 ± 1.8	413.6 ± 8.3
Zeranol	331.5 ± 3.8	333.3 ± 3.1	382.3 ± 3.1	318.1 ± 6.3	376.6 ± 3.3	316.5 ± 8.3
Breed of sire						
Brahman	328.2 ± 4.3***	356.2 ± 6.3***	398.2 ± 3.3***	384.6 ± 6.2+	380.7 ± 3.6	318.2 ± 3.2
Romana Red	301.3 ± 5.1	333.6 ± 3.1	363.6 ± 3.2	370.7 ± 3.1	366.6 ± 6.6	311.3 ± 1.1
Breed of dam						
Angus	306.8 ± 3.0*	328.6 ± 8.1*	351.3 ± 5.1**	373.1 ± 3.8	368.3 ± 3.8	312.8 ± 3.6
F1 Angus Brown Swiss	323.6 ± 8.3	343.3 ± 3.8	383.8 ± 4.3	318.3 ± 3.3	318.3 ± 3.1	321.8 ± 3.2
Birth year of cow						
1981	323.8 ± 4.8**	318.2 ± 3.9**	394.3 ± 3.9***	386.1 ± 3.3	313.6 ± 8.1	333.6 ± 8.3***
1982	305.3 ± 4.6	333.5 ± 3.6	359.6 ± 3.6	368.7 ± 6.1	371.3 ± 3.3	398.5 ± 8.2

+P < .10

*P < .05

**P < .01

***P < .001

[a] Zeranol × breed of sire interaction affected (P < .05) weight at palpation for second pregnancy

[b] The NC females differed (P < .05) from (SC + NC)/2 for weight at beginning and end of first and second breeding seasons and at palpation for first and second pregnancies. The SC group differed (P < .10) from the LC group at the end of the second breeding season

TABLE 3. LEAST SQUARES ESTIMATES ± SE FOR WEIGHT AND CONDITION SCORE OF THE COWS AT DIFFERENT STAGES OF DEVELOPMENT

Source of variation	Weight, kg			Condition score		
	Start of third breeding season	End of third breeding season	Palpation for third pregnancy	Start of first breeding season	End of first breeding season	Palpation for first pregnancy
Creep treatment[a]						
No creep (NC)	418.8 ± 14.4	414.8 ± 13.6	431.2 ± 14.8	7.21 ± .22	6.73 ± .24	6.39 ± .20
Short-term (SC)	491.6 ± 21.8	482.4 ± 21.1	491.3 ± 22.8	8.03 ± .21	8.65 ± .22	9.09 ± .20
Long term (LC)	442.8 ± 15.8	434.2 ± 15.1	454.0 ± 16.3	8.28 ± .21	8.14 ± .23	9.24 ± .16
Zeranol treatment						
No zeranol	453.4 ± 14.5	441.6 ± 14.3	450.1 ± 16.2	7.95 ± .10	8.74 ± .18	6.31 ± .16
Zeranol	455.4 ± 14.4	444.1 ± 14.6	462.6 ± 15.1	8.31 ± .11	8.68 ± .18	6.10 ± .14
Breed of sire						
Brahman	462.3 ± 13.3	458.2 ± 12.6	473.1 ± 13.6	8.30 ± .14*	8.18 ± .11**	9.49 ± .15*
Romana Red	446.2 ± 16.4	428.8 ± 16.6	459.9 ± 11.2	1.66 ± .16	8.25 ± .20	8.98 ± .18
Breed of dam						
Angus	442.6 ± 14.1	439.1 ± 16.1	458.1 ± 17.4	8.41 ± .19**	6.35 ± .20**	6.41 ± .18**
F1 Angus-Brown Swiss	456.3 ± 13.3	448.8 ± 12.9	461.3 ± 13.9	7.57 ± .16	6.36 ± .18	6.86 ± .14
Birth year of cow						
1961	—	—	—	7.82 ± .10	6.80 ± .19*	10.94 ± .17***
1962				8.14 ± .17	6.31 ± .18	7.44 ± .16

*P < .05
**P < .01
***P < .001

[a] The NC cows differed (P < .14) from (SC + LC)/2 for weight at beginning and end of third breeding season and at palpation for third pregnancy. The SC cows differed from LC cows (P < .10) for weight at end of the third breeding season.

and Holloway and Totusek (1973b) observed that difference between creep-fed and noncreep-fed heifers disappeared by 2 years of age. However, persistence of the weight difference after weaning can be influenced by the postweaning nutritional level. Burns and Koger (1963) and Martin et al. (1981) showed that creep-fed males, receiving fattening diets in feedlot, maintained throughout the finishing period the weight superiority they had at weaning. Pritchard (1983) showed that even though the noncreep-fed heifers used in the present study were lighter at weaning than the creep-fed heifers, they exhibited an adequate rate of gain during the preweaning period and a weaning condition score very close to that of creep-fed heifers (10, 11, and 11.3 for noncreep-fed, short- and long-term creep-fed heifers, respectively). Since the noncreep-fed heifers did not suffer a period of restricted growth, they may not have had compensatory growth, which is commonly observed in animals restricted in growth during a period and then placed on a higher nutritional level. In addition, all heifers received supplemental feed after weaning which permitted the creep-fed heifers, already adapted to a concentrate supplement, to maintain a rate of gain comparable to that of the noncreep-fed heifers.

Heifers of the short-term creep feeding groups were heavier ($P < .10$) than those of the long-term creep feeding group at the end of the second and third breeding seasons. No significant differences existed between the two creep treatments at other ages, however, there was a tendency for the short-term creep-fed heifers to be heavier than those of the long-term creep-fed group as age increased.

especially after the beginning of the third breeding season. Data from the beginning of the third breeding season to the palpation for the third pregnancy included only the 30 heifers born in 1981. The data do not provide a logical explanation for the difference observed in growth behavior of heifers of the two creep-fed groups.

Zeranol implanted heifers were significantly heavier at weaning, as shown by Prichard (1983), and were still heavier ($P < .10$) at palpation for first pregnancy (table 2). The difference in weight, however, did not persist to more advanced ages. Staigmiller et al. (1983) reported that heifers implanted with zeranol during a period in drylot still maintained the difference after a summer grazing period, and Mader et al. (1983), comparing the effects of zeranol implanted at different ages on growth of steers, concluded that when implants were discontinued the differences observed in early ages tended not to persist until slaughter time.

There were no significant creep feeding by zeranol interactions on weight of the animals at any postweaning age studied.

Brahman-sired heifers were significantly heavier at weaning than those sired by Romana Red bulls (Prichard, 1983). The weight superiority of the Brahman-sired females persisted after weaning and was still present ($P < .10$) at the beginning of the second breeding season (table 2). After that, no significant difference existed even though the Brahman sired cows tended to be heavier throughout the experiment.

Heifers from Angus-Brown Swiss F_1 dams were significantly heavier than those from Angus dams at weaning (Prichard, 1983). Significant difference in favor of heifers from F_1 dams persisted ($P < .01$) until palpation for first pregnancy, but no significant differences in weight were observed at subsequent ages. The Angus-Brown Swiss F_1 dams, due to higher milk production, provided their offspring with a better maternal environment than did the straightbred Angus dams (Olson, 1980, Euclides et al., 1983) and also transmitted a greater genetic potential for growth (Gregory et al., 1978a). These two factors together with the supplements fed to the heifers after weaning would explain the higher weights until the palpation for first pregnancy, when the heifers were about 19 months old. After first calving, the higher potential for milk production of the heifers from F_1 dams probably accounts for the lack of a weight difference. The heifers from the F_1 cows tended to have a lower body condition throughout the experiment (tables 3 and 4) and were significantly thinner at the times their calves were weaned. The heifers from F_1 dams were significantly taller at the hip at all ages measured (table 5).

The difference observed by Prichard (1983) in condition score at weaning between creep-fed and noncreep-fed groups had been erased by the beginning of the first breeding season (table 3). These findings concur with the results of Holloway and Totusek (1973a). In the present study, however, the creep-fed heifers had higher ($P < .10$) condition scores at the end of the third breeding season and at palpation for third pregnancy, when compared to noncreep-fed heifers. The higher condition score of creep-fed animals at these two times was primarily due to the fact that the short-term creep-fed females had higher average condition scores than the other two groups, with the long-term creep-fed females having slightly higher scores than the noncreep-fed females.

TABLE 4 LEAST SQUARES ESTIMATES ± SE FOR CONDITION SCORE OF THE COWS AT DIFFERENT STAGES OF DEVELOPMENT

Source of variation[a]	Start of second breeding season	End of second breeding season	Palpation for second pregnancy	Start of third breeding season	End of third breeding season	Palpation for third pregnancy
Creep treatment[b]						
No creep (NC)	6.24 ± .31	6.13 ± .29	6.61 ± .00	6.11 ± .88	6.16 ± .34	6.49 ± .29
Short term (SC)	6.11 ± .30	6.78 ± .37	6.64 ± .19	7.06 ± .58	7.35 ± .49	7.61 ± .41
Long-term (LC)	6.61 ± .35	5.95 ± .35	6.61 ± .23	7.28 ± .39	6.65 ± .34	6.84 ± .26
Zeranol treatment						
No zeranol	6.47 ± .29	6.73 ± .25	6.91 ± .18	7.61 ± .35	6.54 ± .31	6.92 ± .26
Zeranol	6.15 ± .36	5.97 ± .42	6.76 ± .16	7.54 ± .39	6.66 ± .33	7.08 ± .28
Breed of sire						
Brahman	6.70 ± .26	6.58 ± .23	6.38 ± .16	7.36 ± .36	7.08 ± .31	7.04 ± .26
Romana Red	6.12 ± .20	6.61 ± .24	6.12 ± .16	7.26 ± .41	6.61 ± .34	6.61 ± .29
Breed of dam						
Angus	6.91 ± .29**	5.98 ± .26	7.11 ± .18***	7.68 ± .34	6.67 ± .34	7.86 ± .29*
F_1 Angus Brown Swiss	5.08 ± .26	6.21 ± .22	6.39 ± .16	6.69 ± .38	6.09 ± .31	6.55 ± .26

*P < .05
**P < .01
***P < .001

[a] The interactions creep feeding x zeranol and zeranol x breed of dam affected (P < .08) condition score at palpation for second pregnancy.

[b] The NC cows differed from (SC + LC)/2 (P < .10) for condition scores at end of third breeding season and at palpation for third pregnancy.

There was no significant difference in condition score of heifers in the two zeranol treatment groups at weaning (Prichard, 1983) or at any subsequent age (tables 3 and 4).

Brahman-sired heifers had significantly higher condition scores than Romana Red-sired heifers at the beginning and end of the first breeding season and at palpation for first pregnancy (table 3). The difference did not persist, however, at subsequent ages (table 4). This was probably a consequence of higher nutritional demand for lactation of the Brahman-sired heifers, since all condition scores recorded after the first palpation for pregnancy coincided with the end of the two lactation periods of the cows, and Brahman-sired cows produced more milk and weaned heavier calves than did those sired by Romana Red bulls.

Least square estimates for hip height at the time heifers were palpated for pregnancy in the three years are shown in table 5. Creep treatment did not affect ($P > .10$) hip height of the heifers at any age studied. This agrees with results reported by Crichton et al. (1959), who observed that wide differences in feeding level had a great influence in live weight but only a small effect on skeletal growth.

Zeranol implanted heifers tended to be shorter at hip than the nonimplanted controls at the palpations for first and second pregnancies and were shorter ($P < .10$) at palpation for third pregnancy. No information exists in the literature on the effects of zeranol implants, at early age, on height of the animals at a more advanced stage of maturity. However, results from Unruh et al. (1983), with males, showed a tendency for reduction in height of animals implanted with zeranol. In their work, nonimplanted bulls and

TABLE 6. LEAST SQUARES ESTIMATES ± SE FOR HEIGHT AND REPRODUCTIVE TRAITS AT DIFFERENT STAGES OF DEVELOPMENT

Source of variation[a]	Height, cm: Palpation for first pregnancy	Height, cm: Palpation for second pregnancy	Height, cm: Palpation for third pregnancy	Heifers cycling at beginning of first breeding season %	Pregnancy rate at first breeding %	Rebreeding at[c] second and third breedings %
Creep treatment[b]						
No creep (NC)	125.61 ± .74	128.19 ± .97	129.21 ± 1.00	43.35 ± 7.21	68.15 ± 7.83	87.68 ± 5.51
Short term (SC)	126.50 ± .72	129.33 ± 1.14	129.65 ± .60	53.15 ± 6.96	61.60 ± 6.95	60.91 ± 4.24
Long-term (LC)	125.43 ± .72	128.20 ± .95	130.16 ± 1.13	68.46 ± 6.96	68.25 ± 7.50	92.01 ± 5.42
Zeranol treatment						
No zeranol	125.86 ± .63	129.43 ± .68	131.11 ± .89*	53.22 ± 5.82	75.05 ± 5.60	93.08 ± 4.61*
Zeranol	125.38 ± .59	128.69 ± .78	128.80 ± .93	55.86 ± 5.13	58.19 ± 5.71	80.32 ± 4.54
Breed of sire						
Brahman	126.49 ± .55*	129.29 ± .76	130.95 ± .83	74.08 ± 5.26***	68.63 ± 5.29	83.43 ± 4.63
Romana Red	124.83 ± .64	127.93 ± .61	128.58 ± .93	34.99 ± 5.68	62.77 ± 5.29	89.91 ± 4.68
Breed of dam						
Angus	123.61 ± .63**	126.77 ± .87**	127.73 ± .95***	42.56 ± 5.85**	92.82 ± 5.22	80.93 ± 4.51
F1 Angus Brown Swiss	128.22 ± .56	130.35 ± .79	132.09 ± .81	68.51 ± 5.41	85.61 ± 5.29	86.45 ± 4.44
Birth year of cow						
1981	125.45 ± .61	128.15 ± .86	129.55 ± .89	75.29 ± 6.36	67.29 ± 5.96	83.60 ± 3.86
1982	124.87 ± .58	128.91 ± .82	130.37 ± .93	33.77 ± 5.80	60.38 ± 5.55	85.47 ± 3.63

*P < .10

**P < .05

***P < .01

[a] The creep feeding x zeranol interaction affected (P < .05) height at first palpation for pregnancy and percent of heifers cycling at beginning of first breeding season. The zeranol x breed of sire interaction affected (P < .05) height at palpation for first pregnancy. Rebreeding was affected by age of cow (P < .05) and by the zeranol x age of cow interaction (P < .001). Age of the heifer at beginning of the first breeding season, included as a covariate in the studies of cycling status and pregnancy rate at first breeding season, did not affect (P > .30) the traits. The covariate age of the calves at beginning of breeding season did not affect rebreeding.

[b] Percent of heifers cycling at beginning of the first breeding season for NC group was lower (P < .10) than the value for (SC + LC)/2.

[c] Year for rebreeding refers to year in which data were collected.

bulls implanted only until weaning were significantly taller than bulls implanted from weaning to slaughter and steers implanted from birth to slaughter. Results on carcass weight indicate that differences in animal weight could not explain all differences in height between treatment groups. A physiological basis for possible reduction in height of the animals implanted with zeranol could be related to the estrogen-like activity of zeranol referred to by Johnson (1984), who stated that zeranol can mimic many of the biological and molecular effects of estrogens. According to Silberberg and Silberberg (1971), estrogens exert three major effects on structure of the skeleton: inhibition of linear growth, acceleration of skeletal development, and condensation of bone. They also affirmed that, in growing individuals of all species of mammals and birds investigated, estrogen inhibited growth of long and flat bones and accelerated skeletal development by hastening epiphyseal closure and by determining premature appearance of centers of ossification.

Heifers sired by Brahman bulls were taller at the hip at palpation for pregnancy ($P < .10$) than those sired by Romana Red bulls, and tended to be taller at subsequent measurement times. No data exist in the literature on height of animals of the Romana Red breed, but lower values for height of animals sired by Romana Red bulls in the present study are supported by the lower values for frame score at weaning reported by Prichard (1983) for Romana Red-sired calves.

Heifers from F_1 Angus-Brown Swiss dams were significantly taller at all ages studied than those from Angus dams. This is in agreement with the values for frame score observed by Prichard (1983) and is a consequence of the larger frame of the Brown Swiss breed.

The proportion of heifers cycling at the beginning of the first breeding season is shown in table 5. Age of heifer at the beginning of the first breeding season was used in the model as a covariate, but did not affect cycling status. A higher proportion ($P < .10$) of the creep-fed heifers was cycling at the beginning of the first breeding season than of the noncreep-fed heifers. This probably was a consequence of the heavier weight of the creep-fed heifers at the beginning of the breeding season. Authors have consistently reported the existence of a close relationship between live weight and onset of puberty (Crichton et al., 1960; Reid et al., 1964; Cohen et al., 1980; Wiltbank, 1983)

Even though zeranol implants increased weight of heifers, it did not affect the proportion of heifers cycling at the beginning of first breeding season. Zeranol was shown to inhibit ovulation in gilts when implanted after puberty (Etienne and Jemmali, 1982). It is unlikely that the absence of an increase in the proportion of heifers cycling in the present study, in response to increased weight due to zeranol implants, could be a consequence of an inhibitory effect of zeranol on ovulation. Heifers were last implanted 146 days of age, and according to Staigmiller et al. (1983) no differences in weight and age at puberty were observed in heifers implanted with zeranol at ages of 8 to 11 months.

A higher proportion ($P < .001$) of heifers sired by Brahman bulls was cycling at beginning of the first breeding season than of heifers sired by Romana Red bulls. No information exists about the precocity of animals of the Romana Red breed.

A higher proportion ($P < .01$) of heifers from F_1 Angus-Brown Swiss dams was cycling at the beginning of the first breeding season than of the heifers from Angus dams. This may be explained as a consequence of the higher milk production of the F_1 cows (Olson, 1980, Euclides et al., 1983), which resulted in heavier weights and, consequently, earlier puberty, plus a genetic influence of the Brown Swiss component reducing age at puberty (Gregory et al., 1978b; Pinedo, 1979).

The differences observed in proportion of heifers cycling at beginning of the first breeding season did not result in any difference ($P > .10$) in pregnancy rate among treatments in the first breeding season (table 5). This indicates that many heifers not cycling before the beginning of the breeding season showed estrus during the breeding season and became pregnant. The partial correlation between cycling status at beginning of first breeding season and pregnancy was low, $r = .18$ ($P > .13$). Heifers in all treatment groups attained an average weight of at least 300 kg at the beginning of the breeding season. At this weight, a high proportion of 15-month-old heifers of most beef breeds and crossbreds is expected to be cycling (Wiltbank, 1983). An analysis of age of calf at weaning, reported in Study II of this series (table 19), demonstrated consistently that calves from treatment groups which had a higher proportion of heifers cycling at the beginning of the first breeding season tended to be older at weaning, indicating that their dams became pregnant earlier in the breeding season, even though there was no significant difference in pregnancy rate.

The percentage of heifers rebreeding in successive years per treatment group is shown in table 5. Creep feeding did not affect ($P > .25$) rebreeding percentage. This result concurs with those reported by Holloway and Totusek (1973b) and Little and Kay (1979), who did not observe negative effects of creep feeding on future calving and weaning rates. However, Martin et al. (1981), in a long-term study, concluded that creep feeding reduced the number of calves weaned during the cow's lifetime.

Percentage of rebreeding was lower ($P < .10$) in zeranol implanted cows than in the non-implanted controls. There was, however, an interaction ($P < .001$) between zeranol treatment and age of the cow (table 6). Zeranol treatment did not significantly affect rebreeding performance of 2-year-old cows and did not affect pregnancy rate as yearlings (tables 5 and 6). In fact, zeranol implanted heifers tended to have higher pregnancy rates at these times. Biologically, it is not probable that a treatment applied during the sucking period of the heifer would not have any negative effect on the pregnancy rate in the two first breeding seasons but would manifest a negative effect at third breeding season. The analysis of pregnancy rate at the third breeding season was based only on 30 heifers born in 1981. A possibility exists that the lower pregnancy rate observed for the zeranol implanted heifers at the third breeding season may have been due to sampling error. No negative effect of zeranol implanted preweaning on the future reproductive performance of heifers was observed by Corah (1980). However, the same author concluded that 36

TABLE 6 LEAST SQUARES ESTIMATES ± SE FOR REBREEDING PERCENTAGE BY ZERANOL TREATMENT AND AGE OF COW

Zeranol treatment	Age, years	
	2	3
No zeranol	92.31 ± 5.20	100.00 ± 7.07
Zeranol	94.71 ± 4.66	54.64 ± 7.58

mg of zeranol implanted postweaning depressed fertility of heifers. Depressive effects of zeranol implanted postweaning were observed also by Nelson et al. (1972). Staigmiller et al. (1983) implanted zeranol in heifers at ages of 8 to 11 months, in two trials, and concluded that in the first trial zeranol depressed pregnancy rate (62% vs. 78%) but had no adverse effect in the second trial (88% vs. 87%).

Breed of sire and breed of dam did not affect ($P > .20$) rebreeding. All groups of cows involved in this study were *Bos indicus*-*Bos taurus* crossbreds and this condition is expected to bring to all groups some heterosis for fertility (Turner et al., 1968; Bazer, 1973; Cartwright, 1973).

Age of the cow affected ($P < .05$) rebreeding. The rebreeding percentage for lactating 2-year-old cows was 94.72% versus 78.68% for the 3-year-olds. This does not coincide with the expected, since the stress of lactation tends to depress the rebreeding more in younger cows (Reynolds et al., 1979). However, in the present study the low rebreeding percentage in 3-year-old zeranol implanted cows caused the reduced fertility observed for the 3-year-olds because 100% of the non-implanted 3-year-old cows became pregnant (table 6).

To evaluate the influence of milk yield and condition score on rebreeding rate, analyses were performed including these parameters as covariates. They did not affect significantly the rebreeding performance.

Least squares estimates for pelvic area, measured at the beginning of the first breeding season and just prior to the first calving season, are shown in table 7. All factors that increased weight increased pelvic area at beginning of the first breeding

TABLE 7. LEAST SQUARES ESTIMATES ± SE FOR PELVIC AREA AT BEGINNING OF FIRST BREEDING SEASON AND PRIOR TO FIRST PARTURITION

Source of variation[a]	Pelvic area, cm^2 Beginning of first breeding season	Pelvic area, cm^2 Beginning of first calving season
Creep treatment[b]		
No creep (NC)	167.73 ± 4.03	228.38 ± 5.24
Short-term (SC)	174.75 ± 3.88	234.39 ± 4.77
Long-term (LC)	178.63 ± 3.94	239.17 ± 5.68
Zeranol treatment		
No zeranol	165.73 ± 3.27***	236.27 ± 4.28
Zeranol	181.60 ± 3.19	231.66 ± 4.18
Breed of sire		
Brahman	180.75 ± 2.93**	235.45 ± 3.86
Romana Red	166.53 ± 3.52	232.53 ± 4.71
Breed of dam		
Angus	162.53 ± 3.42***	225.67 ± 4.64**
F_1 Angus-Brown Swiss	184.75 ± 3.03	242.27 ± 3.87
Birth year of cow		
1981	169.86 ± 3.43	243.12 ± 4.43**
1982	177.42 ± 3.26	224.82 ± 4.25

**$P < .01$
***$P < .001$

[a] Age at beginning of the breeding season affected ($P < .10$) pelvic area at beginning of the breeding season. Creep feeding x breed of sire x breed of dam ($P < .05$), creep feeding x zeranol x breed of dam ($P < .10$), and breed of sire x breed of dam affected pelvic area at beginning of the first breeding season.

[b] Pelvic area for NC group was smaller ($P < .10$) than for (SC + LC)/2 at the beginning of the first breeding season.

season. Increases due to creep feeding tended, however, to be less evident than increases due to zeranol implant, breed of sire, and breed of dam. This is supported by the conclusions of Crichton et al. (1959) that high nutritional levels had a greater influence on live weight than on skeletal growth.

Brahman-sired heifers and those from F_1 dams had larger pelvic areas at the beginning of first breeding season. Differences between breed groups were apparently consequences of differences in weight and skeletal size. Sire and dam breeds associated with increased weight and height of the animals were associated also with larger pelvic areas.

In agreement with the results of the present study, increases in pelvic area in response to zeranol implants have been reported previously. Corah (1980) observed an increase in pelvic area of yearling heifers that had been implanted with zeranol at weaning, and Ellington et al. (1978) observed larger pelvic areas at weaning in heifers that had been implanted with zeranol during the suckling period. Also, Staigmiller et al. (1983) concluded that heifers implanted with zeranol at 9 to 11 months of age had larger pelvic areas at the beginning of the first breeding season and at palpation for first pregnancy. Anthony et al. (1981), however, reported that increases in pelvic area observed when pregnant heifers were implanted with zeranol tended to be erased as pregnancy advanced.

In general, differences in pelvic area observed between treatment groups at beginning of the first breeding season tended to disappear by the time measurements were taken prior to first calving. At that time, the heifers from F_1 dams still had a larger average pelvic area than did the heifers from Angus dams.

Partial correlations between pelvic area at beginning of the first breeding season and weight at beginning of the first breeding season and height at first palpation for pregnancy were, respectively, 37 ($P < .0022$) and .40 ($P < .0008$). The partial correlation between pelvic area and weight prior to first calving was .52 ($P < .0001$) and between pelvic area prior to first calving and height at palpation for first pregnancy was .45 ($P < .0008$). These correlations show that pelvic area tended to increase according to general growth of the heifers.

Summary

Data collected on 44 heifers born in 1981 and 48 heifers born in 1982, from Angus (A) and Angus-Brown Swiss F_1 (F_1) dams and sired by Brahman (B) and Romana Red (RR) bulls, were used to study the effects of creep feeding and zeranol implants during the suckling period on growth and reproductive performance of beef females. Creep feeding treatments were no creep (NC), creep feeding from 146 days of age to weaning (SC), and creep feeding from 56 days of age to weaning (LC). Part of the heifers in each treatment group were implanted with 36 mg of zeranol at 56 days of age and reimplanted 90 days later. The creep-fed heifers were significantly heavier at all ages studied and had higher condition scores at the beginning of the first breeding season, at the end of the second and third breeding seasons, and at palpation for third pregnancy. The SC females were heavier ($P < .10$) than LC females at the end of the second and third breeding seasons

Creep feeding and zeranol implants significantly increased pelvic area of yearling heifers at the beginning of the first breeding season, but not just prior to first calving as 2-year-olds. Zeranol implants significantly increased weight of the heifers until palpation for first pregnancy, reduced ($P < .10$) hip height at palpation for third pregnancy, but did not significantly affect the proportion of heifers cycling at the beginning of the first breeding season or condition score at any age studied. No differences in pregnancy rate were observed between zeranol treatment groups at the first and second breeding seasons, but pregnancy rate was lower ($P < .10$) in the implanted group at the third breeding season. The B-sired females were significantly heavier than those sired by RR bulls until the beginning of the second breeding season, were significantly taller at the hip at the palpation for first pregnancy, and tended to be heavier and taller at all subsequent ages. The B-sired heifers had a significantly higher body condition score than RR-sired heifers at the beginning and end of the first breeding season. Pelvic area was significantly larger at the beginning of the first breeding season in B-sired heifers and those from F_1 dams than in heifers sired by RR bulls and those from A dams. The differences between breed groups of dam still existed at the measurement made prior to first calving at 2 years of age. A higher proportion ($P < .001$) of B-sired heifers and those from F_1 dams ($P < .01$) were cycling at the beginning of the first breeding season than of RR-sired heifers and those from A dams. No differences in pregnancy rates were observed between breed groups of sire or dam. Females from F_1 dams were significantly heavier than those from A dams until palpation for first pregnancy, were significantly taller, and tended to have lower condition scores at all ages studied.

STUDY II
MATERNAL ABILITY

Introduction

Creep feeding and growth stimulant implants have been used to increase the weaning weight of beef calves. Creep-fed heifers weaned lighter calves, as cows, than noncreep-fed heifers (Holloway and Totusek, 1973b, Martin et al., 1981). This is due to a lower milk production by the creep-fed animals (Holloway and Totusek, 1973b).

Little information exists on the effects of zeranol on future maternal ability of heifers. Corah (1980) did not find a difference in milk production between control and implanted heifers, however, Morrison et al, cited by Johnson (1984), observed that heifers implanted at weaning produced more milk as cows than did non-implanted heifers.

This study was designed to evaluate the effects of creep feeding and preweaning zeranol implant on future maternal ability of crossbred heifers.

Experimental Procedure

A complete description of the animals used in this study, along with a detailed description of the nutritional and general management programs, was presented in Study I. From a total of 106 cows calving in 1983 (37) and 1984 (69), nine were eliminated from this study due

TABLE 8 NUMBER OF COW-CALF PAIRS BY BREED OF SIRE, BREED OF DAM, CREEP FEEDING, AND ZERANOL TREATMENTS

Breed of sire	Creep feeding	Breed of dam			
		Angus		F_1 Brown Swiss-Angus	
		Zeranol	No Zeranol	Zeranol	No Zeranol
Brahman	No creep	5	5	7	3
	Short-term	6	3	2	3
	Long-term	3	6	4	6
Romana Red	No creep	3	3	5	4
	Short-term	1	1	4	5
	Long-term	5	2	5	5

to cows claiming the same calf (2), stillborn calves (5), and calves sacrificed due to congenital problems (2). The number of cow-calf pairs included in the study by breed of sire, breed of dam, zeranol, and creep feeding treatment are shown in table 8.

Calves were born from January to early March each year and were tagged, weighed, and male calves castrated within 24 hours of birth. Cows were grouped into six milking groups each year, according to calving date, in such a way that the extreme ages of the calves at each milking would not deviate from the average by more than 7 to 8 days. Cows were milked each year at about days 30, 70, 120, and 190 of lactation.

Milk production was measured in 1983 by the calf-weight-change method and by hand-milking. Cows were penned with their calves 2 days before milking and received corn silage and hay ad libitum while penned. Cows were separated from the calves at about noon the day prior to the milking and 7 to 8 hours later calves were allowed to nurse, to guarantee complete milk withdrawal. The time the calf completed nursing was recorded. The calves were then maintained separated from their dams until about 6:00 to 6:30 a.m. the next day, at which time each calf was weighed, allowed to nurse, and then weighed again. The time the calf finished nursing was recorded to permit determination of the secretion period. The calves were again maintained separated from their dam for an additional 4- to 6-hour period. After that, cows were restrained in a squeeze chute, given an intramuscular injection of 30 IU of oxytocin, and the milk from the right fore and rear quarters was removed by hand milking. Time at end of milking was recorded to permit calculation of the secretion period, and the milk was weighed. The milk yield obtained by hand milking was multiplied by two to permit an estimate of the production for the four quarters. Estimates of the milk production obtained by the hand milking and calf-weight change methods were combined and production was adjusted to a 24-hour basis. This procedure was used because some Romana Red-sired cows were very nervous, by the morning after overnight separation from the calves, and visual observation revealed that some of them did not stand still long enough for their calves to complete nursing. Thus, it was thought that in some instances there was incomplete milk removal by the calves. This also would have resulted in an overestimation of milk production from the hand milking. The two methods combined should result in the best estimate of actual production.

In 1984, cows were machine milked about 1 minute after an IM injection of 30 IU of oxytocin. Following machine milking, the udders were stripped by hand. All other procedures utilized were the same as those used in 1983.

Representative samples of .3 kg of milk obtained by hand milking in 1983 and by milking machine in 1984 were taken for analysis from all cows at each milking. The percentages of fat, protein, and total solids in the milk were determined by AOAC (1980) methods.

At weaning calves were weighed, hip heights were measured, and calves were subjectively scored for frame size and body condition using scales of 1 to 6 and 1 to 17, respectively (Andrade, 1980).

Statistical analyses were performed using the General Linear Models (GLM) procedure of the Statistical Analysis System (SAS), 1982 release.

Cow traits considered were milk yield and percentages of fat, protein, and total milk solids at about days 30, 70, 120, and 190 days of lactation.

Calf traits studied were birth weight, calf weight at about 30, 70, 120, and 190 days of age and at weaning, 205-day weight, daily weight gains in the successive periods from birth to 30, 30 to 70, and 70 to 190 days of age, and hip height, body condition score and frame score at weaning

Data were analyzed by the method of ordinary least squares analysis of variance.

Because the milking methods used in 1983 were different from the method used in 1984, initial analyses were conducted for milk yield and milk components to determine if there were any interactions between method of milk removal and treatment effects. Results of these analyses showed that no important interactions existed, thus, data from the 2 years were pooled into a single data set and milking method was disregarded.

In calculation of average values for milk production and for percentages of milk components, cows with more than one missing observation were excluded. For animals with one missing record, a missing value was calculated by multiplying the average value of the three existing records of the animal by a factor that was specific for each year and each stage of lactation. Each adjustment factor for a given year was the ratio between the value of the corresponding record and the average of the three other records, as calculated from the records of cows with no missing information.

The 205-day weight was calculated by adding to calf's birth weight the daily weight gain multiplied by 205.

Several mathematical models were used. Because repeated measurements were taken on each animal for all traits, cow nested within the treatment combinations was included in the model and used as the error term to test main effects and interactions among treatments.

As a general procedure in the analyses for all traits, the first step was to use a reduced model containing only the effects of mean, cow and fixed effects like year, age of the cow, etc. Effects of cow and the mean were absorbed. A second analysis was performed using a model containing the main effects of treatments, all possible interactions among treatments and other fixed effects included in the reduced model, but not containing the random effect of cow. Sums of squares for cows were obtained by reduction in sums of squares when fitting the two models. The mean squares for cow nested within treatment combinations was used in the second model to perform F-tests. A third simplified model, containing only the main effects of treatments, significant interactions, and nonsignificant interactions contained in higher order significant interactions, as well as other significant fixed effects, was used to obtain the least squares estimates.

Regression analyses of daily milk production, percentages of protein, fat, and total solids in the milk on day of lactation were performed. To determine the proper degree polynomial, as well as to test for homogeneity of slope, reduced models were used. In testing significant polynomial degree, a model including only the effects of mean, cow and the polynomial was used, and the effects of mean and cow were absorbed. To test homogeneity of slope two analyses involving reduced models were performed for each main effect. The first model included only cow nested within the main effect and the polynomial up to the highest significant degree. In the second model, the polynomial was replaced by the interaction between main effect and each term of the polynomial. Homogeneity of slope was tested by the difference in reduction in sums of squares by fitting the different models. When heterogeneity of slope was observed, a separate regression analysis was performed for each level of the effect.

Relationships between the yields of milk and total milk solids with calf development-related traits, at different phases of the preweaning period, were evaluated by examining partial correlations that were adjusted for the treatment effects and for the effects of all possible interactions among treatments.

The partial correlations included correlations between average milk yield on the four milking days and calf weight, body condition score, frame score and hip height at weaning and calf gain from birth to weaning, and correlations between average yield of total solids and calf weight at weaning and calf gain from birth to weaning.

Repeatabilities of milk yield, percentage of milk components and calf traits at weaning were estimated by intraclass correlation, using the following equation:

$$T = \frac{\sigma^2{}_B}{\sigma^2{}_B + \sigma^2{}_R},$$

where σ^2B is the between cow variance component and σ^2R is the within cow variance component. Standard errors for repeatability estimates were determined using formula suggested by Mather (1955).

Results and Discussion

Milk Production and Composition

Milk yield

Least squares estimates for 24-hour milk yield at days 30, 70, 120, and 190 of lactation and for average milk yield are shown in table 9. Milk yields of noncreep-fed heifers did not differ ($P > .10$) from the average production of the two creep-fed groups at any stage of lactation. Noncreep-fed and short-term creep-fed heifers were very similar in milk yield, and both groups were superior to the long-term creep-fed heifers. Heifers of the long-term creep-fed group produced less milk ($P < .05$) at days 30 and 70 of lactation and had a lower ($P < .05$) average milk yield than did the short-term creep-fed heifers. Holloway and Totusek (1973b) showed that creep-fed heifers tended to produce less milk as cows than noncreep-fed heifers, and Hixon et al. (1982) concluded that creep feeding significantly reduced milk production. Sejrsen (1978), in a review, concluded that a high energy intake during the period of allometric growth of the mammary gland, from 3 to 6 months of age until 2 to 3 months after puberty, depressed future milk production. He concluded that no detrimental effect would occur when a high level of nutrition was supplied after this period. According to him, there is evidence that high energy intake may depress the levels of growth hormone and prolactin and,

TABLE 9. LEAST SQUARES ESTIMATES ± SE FOR 24-HOUR MILK YIELD (KG)

Source of variation[a]	Day of lactation				Weighted average
	30	70	120	160	
Creep treatment[b]					
No creep (NC)	6.00 ± .25	8.00 ± .25	6.71 ± .31	4.33 ± .20	6.14 ± .21
Short term (SC)	6.38 ± .33	6.84 ± .30	6.41 ± .35	6.20 ± .22	5.20 ± .23
Long term (LC)	4.50 ± .25	6.11 ± .33	4.39 ± .31	3.77 ± .20	6.21 ± .21
Zeranol treatment					
No zeranol	4.92 ± .22	6.66 ± .22	6.62 ± .27	6.11 ± .12	5.67 ± .10
Zeranol	5.81 ± .31	6.63 ± .21	6.65 ± .25	6.00 ± .16	5.56 ± .11
Breed of sire					
Brahman	6.56 ± .21***	7.31 ± .21***	6.72 ± .25***	6.73 ± .18***	6.31 ± .13***
Romana Red	6.44 ± .31	6.92 ± .22	6.05 ± .27	3.92 ± .17	4.80 ± .10
Breed of dam					
Angus	6.19 ± .32*	6.20 ± .33**	6.31 ± .38	3.80 ± .19*	6.32 ± .19*
F1 Angus Brown Swiss	6.30 ± .31	7.00 ± .21	6.00 ± .25	6.36 ± .17	5.91 ± .16
Age of cow					
3 years	6.01 ± .14***	6.42 ± .14***	6.05 ± .16**	3.16 ± .15***	6.00 ± .13***
3 years	7.52 ± .32	7.82 ± .35	4.22 ± .36	6.53 ± .21	6.43 ± .25
Year					
1981	6.99 ± .31	4.38 ± .31	5.18 ± .34**	4.88 ± .23*	5.50 ± .28
1982	6.99 ± .17	6.60 ± .18	5.13 ± .19	3.80 ± .12	6.73 ± .13

+P < .10
*P < .05
**P < .01
***P < .001

[a] Creep feeding × zeranol interaction affected (P < .05) milk production at day 70 of lactation. Creep feeding × zeranol × breed of sire interactions affected (P < .01) milk yield at day 30 of lactation. Creep feeding × zeranol × breed of dam interactions affected (P < .05) milk yield at day 30 of lactation.

[b] The SC group differed (P < .05) from the LC group for milk yield at days 30 and 70 of lactation and for milk average.

since these two hormones are of vital importance for the development of the mammary gland, this might be the way overfeeding depresses future milk production.

In the present study, short-term creep feeding did not have a depressive effect on milk yield; however, heifers from this treatment were creep fed only for a short period of time (from about 146 to 210 days of age) and this might prevent any adverse effect of creep feeding on milk production.

Zeranol treatment did not affect milk yield ($P < .10$) at any stage of lactation. This is in agreement with results of Corah (1980), who worked with heifers implanted with zeranol at weaning. However, Morrison et al., cited by Johnson (1984), observed higher milk production in heifers implanted at weaning with zeranol.

Heifers sired by Brahman bulls had a higher average milk production in all stages of lactation studied than did those sired by Romana Red bulls. No data were found in the literature about the level of milk production in the Romana Red breed. The Brahman cattle from which the bulls were obtained had been submitted to selection for weaning weight for many years, and results from Chenette et al. (1962) showed that selection for weaning weight tended to increase milk production.

Heifers from Angus-Brown Swiss F_1 dams tended to produce more milk at all milking days and had a higher average 24-hour milk yield ($P < .05$) than did heifers from Angus dams. The Angus-Brown Swiss F_1 cows produce more milk than Angus cows (Olson, 1980; Euclides et al., 1983) and evidently transmitted to their progeny a higher genetic potential for milk production.

Year did not affect ($P > .40$) average daily milk production but production at day 120 of lactation was higher ($P < .01$) in 1983 and a higher production ($P < .05$) at day 190 of lactation was found for 1984. In the present study, year is confounded with milking method, since different methods were used in the 2 years of the study. However, no significant interaction was observed between year and main effects, in the preliminary analysis, thus indicating that ranking of treatments was not affected by milking method.

Milk production of 3-year-old heifers was significantly higher than the production of the 2-year-olds at all milking days. These results find wide support in the literature. Gaskins and Anderson (1980), in a study involving beef-beef and beef-dairy crossbred cows, concluded that an increase of 1 year in the age of the cow, between the ages of 2 and 4 years, resulted in an increase of 1 kg in average daily milk production. This agrees closely with the 1.23 kg average difference found in this study between 2- and 3-year-old heifers (table 3). Also, Melton et al. (1967) reported that milk production increased as age of cow increased up to 5 years, and Isea (1985) reported that 3-year-old cows produced significantly less milk than older cows and that there was a trend for milk yield to increase as age of cow increased from 3 to 6 years.

Sex of calf did not affect ($P > .30$) milk yield at any milking day. This is in agreement with results from Isea (1985). However, Dickey et al. (1970) concluded that cows nursing male calves tended to produce more milk, while Jeffery et al. (1971), in a 2-year-study, observed a higher production in the first year in cows nursing male calves but in the second year the advantage was for cows nursing heifer calves.

Actual day of lactation for each cow and milking group, introduced as a covariate in the preliminary analysis, did not affect milk yield on the different milking days.

Average milk yields observed in the present work are within the range that has been reported for different breeds of beef cattle. Daily yields reported for the Angus breed varied from 4.8 to 6.6 kg (Melton et al., 1967, Reynolds et al., 1978, Franke and Martin, 1983), for the Brahman values of 6.2 and 6.4 kg were observed by Neidhardt et al. (1979) and Franke and Martin (1983), respectively, and for reciprocal Angus-Brown Swiss F_1 cows, daily milk yields of 6.8 to 8.4 kg were observed (Euclides et al., 1983, Isea, 1985).

Regression of milk production on day of lactation showed a quadratic effect of day on milk yield. Lactation curves are shown in figure 1. Test of homogeneity of slope showed significant interactions between the quadratic effect of day and breed of sire and no significant interaction between day of lactation and breed of dam, creep feeding or zeranol treatment. Milk yields at different days of lactation were fitted by the following equations:

1) for creep feeding and zeranol treatments and breed of dam, milk yield = intercept + .02628 day - .000172 day^2,

2) for Brahman-sired cows, milk yield = intercept + .039158 day - .000229 day^2,

3) for Romana Red-sired cows, milk yield = intercept + .012589 day - .000116 day^2.

The curves showed a tendency of milk yields to reach a peak at about day 70 of lactation. Similar results were observed by Chenette and Frahm (1981), who concluded that milk yield of beef cows increased from first milking, at about day 30 of lactation, to the second milking, at about day 60 of lactation. A peak in milk yield at about day 30 of lactation was observed in Brahman cows by Neidhardt et al. (1979) and in Hereford-British Friesian cows by Somerville and Lowman (1980). Some authors, however, did not observe a clear peak in the lactation curve. Rutledge et al. (1971) observed the same levels of production at days 30 and 60 of lactation and lower yields after that. Gleddie and Berg (1968), working with six age-breed groups, showed that, when the groups were considered individually, three groups tended to show a peak of lactation at day 60 and three groups exhibited a continuous decrease from the first milking. When the groups were pooled, a tendency for a continuous decrease in production was observed. In some cases, when calf-weight-change method for estimating milk production was used, the authors suggest that the peaks observed may have been a consequence of the young calves not being able to consume all the milk their dams were capable of producing.

The shape of the lactation curves (figure 1) shows that Brahman-sired heifers had a greater persistence of production than did Romana Red-sired heifers.

Percent fat

Least squares estimates for percent milk fat at days 30, 70, 120, and 190 of lactation, and the weighted average percent milk fat are

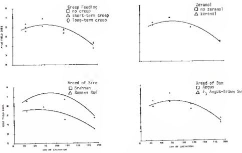

Figure 1. Predicted lactation curves for milk yield by creep feeding, zeranol, breed of sire, and breed of dam.

shown in table 10. The only factors which consistently affected ($P < .01$) percent milk fat were breed of sire and year. Romana Red-sired heifers had a higher milk fat percentage than did those sired by Brahman bulls, and the milk fat percentage was higher in 1983 than 1984. Three-year-old heifers had a higher ($P < .01$) average milk fat percentage (6.02) than the 2-year-olds (5.60), and also had a higher ($P < .05$) fat percentage at day 30 of lactation. No data were found in the literature about percent fat in the milk of Romana Red cows, but results of the present study show that the milk of Romana Red-sired cows is higher in fat content than is the milk of Brahman-sired females. The percentage of milk fat observed for Brahman-sired females in the present study is higher than values normally reported in the literature. The average milk fat estimated for 1984 (5.20%) is relatively close to the values reported for beef cattle by Chenette and Frahm (1981), Chenette et al. (1982), and Franke and Martin (1983). In the present study, year is confounded with milking method, sampling time, and sampling interval, since different procedures were used in the 2 years. Milk samples taken in 1983 for analysis were obtained in the afternoon by hand milking after oxytocin injection and after a secretion period of 4 to 5 hours. In 1984, samples were taken in the morning from milk obtained by machine milking, following oxytocin injection and after a 12- to 13-hour secretion period. The difference in procedures did not affect estimated milk yield for the 2 years (table 9). It did affect milk composition; however, it affected all treatments in the same way. Milk composition may be affected by the length of the test period and by the length of the period which precedes the test period. Elliot (1959) reported that

TABLE 10. LEAST SQUARES ESTIMATES ± SE FOR PERCENTAGE OF MILK FAT

Source of variation[a]	Day of lactation				Weighted Average
	30	70	120	180	
Creep treatment[b]					
No creep (NC)	6.13 ± .19	5.90 ± .18	5.51 ± .13	5.72 ± .15	5.87 ± .12
Short-term (SC)	5.59 ± .22	5.80 ± .20	5.90 ± .15	5.80 ± .18	5.75 ± .11
Long-term (LC)	5.90 ± .14	5.98 ± .17	5.75 ± .13	5.90 ± .18	5.82 ± .11
Zeranol treatment					
No zeranol	6.02 ± .18*	5.93 ± .15	5.64 ± .12	5.67 ± .13	5.87 ± .16
Zeranol	5.56 ± .15	5.93 ± .14	5.80 ± .11	6.12 ± .13	5.78 ± .09
Breed of sire					
Brahman	5.07 ± .15**	5.00 ± .14**	5.39 ± .11***	5.32 ± .18***	5.53 ± .09***
Romana Red	6.11 ± .11	6.28 ± .16	5.43 ± .12	6.02 ± .10	6.13 ± .16
Breed of dam					
Angus	5.18 ± .17	5.98 ± .16	5.89 ± .12	5.90 ± .13	5.78 ± .16
½ Angus Brown Swiss	5.98 ± .15	5.90 ± .14	5.83 ± .11	5.13 ± .12	5.63 ± .09
Age of cow					
2 years	5.54 ± .12*	5.90 ± .12	5.90 ± .09+	5.90 ± .10	6.03 ± .11**
3 years	6.08 ± .22	5.09 ± .22	5.64 ± .17	5.89 ± .19	6.02 ± .10
Year					
1983	6.28 ± .22***	6.63 ± .21***	6.31 ± .16***	6.18 ± .18***	6.92 ± .14***
1984	5.34 ± .12	5.09 ± .12	5.05 ± .09	6.25 ± .10	5.23 ± .08

+P < .10
*P < .05
**P < .01
***P < .001

[a] The zeranol × breed of sire interaction affected (P < .10) milk fat percentage at day 70 of lactation and the zeranol × breed of dam interaction affected (P < .10) milk fat percentage at day 180 of lactation.

[b] Milk fat percentage for NC group was higher (P < .10) than for (SC + LC)/2 at day 30 of lactation.

percent milk fat was 8% after a secretion period of 1 hour and 4% after a 14-hour interval. A carryover effect of a long secretion period on a subsequent 4- to 6-hour secretion period resulted in an overestimation of milk fat (Le Du et al., 1978). According to Elliot (1959), a long secretion period caused a retention of residual fat, fat which remained in the udder even after injection of oxytocin, and increased the fat content of milk in the subsequent milking. In addition, Gilbert et al. (1973) demonstrated that, even when cows were milked at 12-hour intervals, milk obtained in the afternoon tended to be higher in fat content. A combination of the above factors plus the use of oxytocin injection that caused removal of some of the residual milk that was much richer in fat than normal milk (Tucker, 1980) caused the milk samples obtained in 1983 to have a very high fat content.

Regression of percentage of milk fat on day of lactation showed a cubic effect for day on percentage of fat. No interactions between main effects and day of lactation were observed, and variation in the percentage of milk fat for the different main effects was fitted by the following equation:

$$\% \text{ fat} = \text{intercept} + .02741881 \text{ day} - .00031294 \text{ day}^2 + .0000069578 \text{ day}^3.$$

The predicted curve for percent milk fat by creep feeding, zeranol, breed of sire, and breed of dam are shown in figure 2.

According to Tucker (1980), fat percent in the milk of dairy cows tended to decrease in the first 2 to 3 months of lactation and then increased up to the end of lactation. Maynard et al. (1978) stated

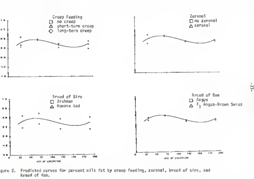

Figure 2. Predicted curves for percent milk fat by creep feeding, zeranol, breed of sire, and breed of dam.

that fat is the most variable component of the milk, and that variations occur among breeds, from milking to milking, and from quarter to quarter, and also milk fat is affected by the diet. In the present study, factors such as stress at milking time, use of supplements during the winter, and variation in the quality of pastures throughout the experiment may explain the variation observed in milk fat percent. However, the largest variations in milk fat percent in the present study were small, not exceeding .5%.

Percent protein

Values of milk protein percent at the different stages of lactation and average milk protein percent are shown in table 11. Breed of sire was the factor which most consistently influenced percent protein in the milk. Heifers sired by Romana Red bulls had a higher percentage of milk protein at all stages of lactation than did heifers sired by Brahman bulls. This result is supported by the higher percentage of fat in the milk of Romana Red-sired heifers, since a high positive correlation exists between milk fat percent and milk protein percent (Christensen, 1968). Age of the cow influenced significantly milk protein percent. Milk of 3-year-old cows was higher in protein content at days 30 ($P < .001$), 190 ($P < .05$), and had a higher ($P < .01$) average percent protein (table 11).

The percentages of milk protein observed in the present study are, in general, within the range of 3.0 to 3.3% most commonly reported for beef cattle (Schwulst et al., 1966; Chenette et al., 1982, Franke and Martin, 1983).

TABLE 11 LEAST SQUARES ESTIMATES ± SE FOR PERCENTAGE OF MILK PROTEIN

Source of variation[a]	Day of lactation				Weighted Average
	30	78	120	180	
Creep treatment[b]					
No creep (NC)	3.35 ± .01	3.23 ± .01	3.03 ± .01	3.18 ± .09	3.30 ± .10
Short term (SC)	3.33 ± .08	3.20 ± .08	3.01 ± .04	3.22 ± .05	3.18 ± .08
Long term (LC)	3.26 ± .01	3.31 ± .01	2.99 ± .03	3.38 ± .08	3.17 ± .04
Zeranol treatment					
No zeranol	3.30 ± .08	3.28 ± .08	2.95 ± .03	3.31 ± .04	3.15 ± .03
Zeranol	3.33 ± .08	3.22 ± .05	3.08 ± .03	3.31 ± .04	3.18 ± .03
Breed of sire					
Brahman	3.18 ± .08***	3.07 ± .08***	2.79 ± .03***	3.01 ± .08***	3.00 ± .03***
[illegible] Red	3.45 ± .08	3.35 ± .08	3.13 ± .03	3.42 ± .04	3.33 ± .03
Breed of dam					
Angus	3.30 ± .06	3.33 ± .06	3.00 ± .03	3.25 ± .04	3.18 ± .03
F_1 Angus-Brown Swiss	3.31 ± .08	3.29 ± .01	2.93 ± .03	3.10 ± .04	3.18 ± .03
Age of cow					
2 years	3.18 ± .08***	3.18 ± .08	2.86 ± .13	3.14 ± .03*	3.00 ± .04**
3 years	3.48 ± .07	3.27 ± .08	3.05 ± .08	3.29 ± .08	3.26 ± .11
Year					
1983	3.32 ± .01	3.34 ± .01*	2.95 ± .05	3.24 ± .08	3.18 ± .09
1984	3.29 ± .04	3.28 ± .04	2.88 ± .03	3.20 ± .03	3.10 ± .02

+P < .10
*P < .05
**P < .01
***P < .001

[a] The zeranol x breed of dam interaction affected (P < .08) the percentage of milk protein at day 180 of lactation.

[b] Protein percentage for NC group was lower (P < .10) than for (SC + LC)/2 at day 180 of lactation.

Similarly to what was observed for milk fat, the regression of milk protein percentage on day of lactation showed a significant cubic effect of day on percentage of protein in the milk. There were no significant interaction effects between any of the main effects studied and day of lactation on percent milk protein. Variation in the percentage of protein in milk during the lactation for all main effects was fitted by the following equation:

$$\% \text{ protein} = \text{intercept} + .00673901 \text{ day} - .00011458 \text{ day}^2 + .00000042 \text{ day}^3.$$

Predicted curves for percent milk protein by creep feeding, zeranol, breed of sire, and breed of dam are shown in figure 3.

The variations in percentage of protein during the lactation followed a trend similar to that observed in percent milk fat. However, the greatest variation in the value of protein for any main effects did not exceed .25%

Percent total solids

Least squares estimates for the percentage of total milk solids are shown in table 12. Similarly to what was found for percent milk fat, the only factors which significantly affected percent of total milk solids were breed of sire, year, and age of cow. This might be expected, since milk fat is the most variable milk component, and total milk solids vary according to fluctuations in levels of the single milk constituents. Reported values of total milk solids for beef cows vary within the range of 12.85 to 14.35% (Gleddie and Berg,

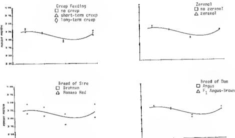

Figure 3. Predicted curves for percent milk protein by creep feeding, zeranol, breed of sire, and breed of dam.

TABLE 12. LEAST SQUARES ESTIMATES ± SE FOR PERCENTAGE OF TOTAL MILK SOLIDS

Source of variation[a]	Day of lactation				Weighted Average
	30	75	120	180	
Creep treatment[b]					
No creep (NC)	14.58 ± .24	14.94 ± .25	14.39 ± .17	14.47 ± .18	14.79 ± .14
Short-term (SC)	14.91 ± .28	14.82 ± .21	14.24 ± .15	14.36 ± .20	14.60 ± .17
Long-term (LC)	15.00 ± .28	14.95 ± .24	14.47 ± .17	14.66 ± .18	14.83 ± .14
Zeranol treatment					
No zeranol	14.26 ± .21	14.88 ± .21	14.29 ± .15	14.41 ± .18	14.78 ± .13
Zeranol	15.12 ± .20	14.95 ± .20	14.24 ± .14	14.63 ± .14	14.73 ± .12
Breed of sire					
Brahman	14.53 ± .29***	14.44 ± .20***	13.79 ± .14***	13.88 ± .18***	14.74 ± .12***
Romana Red	15.05 ± .21	14.38 ± .21	14.74 ± .15	14.35 ± .18	15.27 ± .13
Breed of dam					
Angus	14.75 ± .22	14.90 ± .22	14.35 ± .14	14.43 ± .14	14.77 ± .14
F_1 Angus-Brown Swiss	15.71 ± .18	14.94 ± .19	14.19 ± .14	14.40 ± .14	14.74 ± .12
Age of cow					
2 years	14.71 ± .14**	14.73 ± .16	14.09 ± .09*	14.14 ± .11*	14.82 ± .19***
3 years	15.00 ± .27	15.10 ± .08	14.48 ± .16	14.59 ± .21	14.00 ± .17
Year					
1981	14.71 ± .27***	14.47 ± .27***	14.88 ± .16***	14.57 ± .20	15.25 ± .17***
1982	14.41 ± .14	14.31 ± .14	13.74 ± .08	14.26 ± .11	14.36 ± .09

*P < .05
**P < .01
***P < .001

[a] The zeranol × breed of sire interaction affected (P < .001) total milk solids percentage at day 75 of lactation and the zeranol × breed of dam interaction affected (P < .001) total milk solids percentage at day 180 of lactation.

[b] Percentage of total milk solids for NC was higher (P < .001) than for (SC + LC)/2 at day 30 of lactation.

1968, Chenette and Frahm, 1981, Chenette et al., 1982, Franke and Martin, 1983). Values found in the present study, in general, tended to be higher than those reported in the literature. This was primarily a consequence of the higher milk fat values observed in the present study.

Regression of total milk solids on day of lactation showed a significant cubic effect of day, which was similarly to that observed for fat and protein. No significant interactions between day of lactation and any of the main effects were observed, and values of percent total milk solids at different days of lactation for the main effects were fitted by the following equation.

$$\% \text{ total milk solids} = \text{intercept} + .01903493 \text{ day} - .0003269 \text{ day}^2 + .0000114726 \text{ day}^3.$$

The predicted curves for total milk solids by creep feeding, zeranol, breed of sire, and breed of dam are shown in figure 4. Variations in percent total milk solids followed, as expected, those observed for percent milk fat and percent milk protein. Variations in predicted total milk solids were not large and the largest variation for a given level of main effect did not exceed 1%.

Calf Performance

The weights of the calves at birth and at about 30, 70, 120, and 190 days of age are shown in table 13.

The only factors that significantly influenced birth weight of the calves were sex of calf, age of dam, and year. Male calves were

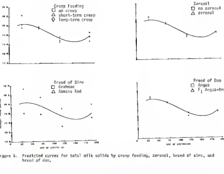

Figure 4. Predicted curves for total milk solids by creep feeding, zeranol, breed of sire, and breed of dam.

TABLE 13. LEAST SQUARES ESTIMATES ± SE FOR CALF WEIGHT (KG)

Source of variation[a]	Calf age				
	Birth	30 days	70 days	120 days	180 days
Creep treatment of dam[b]					
No creep (NC)	31.80 ± .78	53.98 ± 1.75	88.05 ± 1.96	125.73 ± 2.77	189.56 ± 3.58
Short term (SC)	32.76 ± 1.03	56.93 ± 1.35	90.10 ± 2.26	130.22 ± 2.22	195.48 ± 4.75
Long-term (LC)	30.82 ± .75	52.01 ± 1.18	88.24 ± 1.92	127.60 ± 2.77	185.22 ± 3.08
Zeranol treatment of dam					
No zeranol	32.72 ± .77	54.53 ± 1.01	88.81 ± 1.71	125.75 ± 2.08	181.32 ± 3.11
Zeranol	31.30 ± .74	54.02 ± .97	92.38 ± 1.82	128.04 ± 2.28	189.10 ± 2.95
Breed of maternal grandsire					
Brahman	32.20 ± .68	57.02 ± .95***	98.42 ± 1.59***	135.80 ± 2.74***	201.00 ± 2.83***
Hereford Red	31.22 ± .77	51.53 ± 1.03	78.56 ± 1.74	115.76 ± 2.46	173.00 ± 3.96
Breed group of maternal grandam					
Angus	31.78 ± .78	53.86 ± 1.03	91.87 ± 1.75	127.26 ± 2.47	182.77 ± 3.20
F_1 Angus Brown Swiss	32.17 ± .77	54.95 ± .96	88.12 ± 1.58	126.30 ± 2.26	193.11 ± 2.99
Sex					
Male	33.75 ± .77**	57.21 ± 1.10***	93.56 ± 1.88***	132.80 ± 2.72**	201.77 ± 3.00***
Female	30.17 ± .77	51.09 ± 1.17	79.41 ± 1.96	120.72 ± 2.88	179.11 ± 3.09
Age of dam					
2 years	29.17 ± .59***	48.52 ± .81***	79.52 ± 1.44***	118.86 ± 2.08***	170.00 ± 2.81***
7 years	34.86 ± 1.00	59.33 ± 1.38	91.47 ± 2.54	136.91 ± 2.43	203.50 ± 4.00
Year					
1983	33.38 ± 1.09*	56.07 ± 1.53*	90.82 ± 2.09	125.63 ± 2.83	192.61 ± 4.07
1984	30.21 ± .58	52.48 ± .88	87.08 ± 1.46	126.14 ± 2.05	182.57 ± 2.97

*P < .05
**P < .01
***P < .001

[a] The creep feeding x zeranol interaction affected (P < .05) weight of calf at 30 and 120 days of age (P < .05) and weight at 180 days (P < .10). The maternal x breed of maternal grandsire interaction affected weight at 30 and 70 (P < .001), 120 (P < .01), and 180 (P < .10) days of age. Age of calf affected weight at the 30 (P < .001), 70 (P < .10), 120 (P < .05), and 180 (P < .001) days of age.

[b] The SC differed from LC for weight at 30 (P < .05), 70 (P < .10), 120 (P < .05), and 180 (P < .10) days of age.

heavier at birth than females. This concurs with most data reported, including the results of Laster et al. (1973), Nelson and Beavers (1982), and Euclides (1984). Calves from 3-year-old dams were heavier ($P < .001$) than those from 2-year-old dams. This agrees with the results reported by Wilcox (1987) and Nelson and Beavers (1982), who observed that older cows gave birth to heavier calves.

In general, ranking of the treatments in terms of weights of the calves at about 30, 70, 120, and 190 days of age followed the same pattern as that observed for milk production. Calves from cows sired by Brahman bulls were heavier ($P < .001$) than those sired by Romana Red bulls from 30 to 190 days of age. This was due to the fact that Brahman-sired cows produced more milk than Romana Red sired cows (table 9), and also the calves received from the Brahman component a higher genetic potential for growth than that provided by the Romana Red component. This latter was demonstrated by the growth and development of the cows themselves (Study I of this series). The difference in milk production of the dam undoubtedly had the greater effect, since birth weight was not significantly affected by breed of maternal grandsire.

Breed group of maternal granddam did not significantly affect weight of the calf to 190 days of age. Only a slight tendency for heavier weights of calves produced by cows from Angus-Brown Swiss F_1 dams was observed. The differences in milk production between cows from Angus dams and those from Angus-Brown Swiss F_1 dams and the small proportion of the Brown Swiss component present in the calves did not result in heavier calves up to 190 days of age.

Zeranol treatment of the cow had no effect on weight of calf at any age. This was expected since zeranol had no effect on milk production. As was observed for milk production (table 9), the average weight of calves from noncreep-fed cows did not differ from the average weight of calves from all cows that had been creep-fed (table 13). However, calves from short-term creep-fed dams were significantly heavier than those from the long-term creep-fed dams at all milking days, following the same tendency observed in milk yields of the dams.

Steer calves were significantly heavier than heifers at all weighing days. Heavier weights in male than in female calves have been reported by many authors (Koch and Clark, 1955, Laster et al., 1973, Euclides, 1984, Isea, 1985).

Age of cow influenced ($P < .001$) calf weight at all milking days (table 13). Calves from 3-year-old cows were heavier at birth and nursed dams with higher milk production (table 9). Those factors resulted in pronounced heavier weights in calves from the 3-year-old dams. These results are supported by many authors, including Pell and Thayne (1978), Nelson et al. (1982), and Lawlor et al. (1984).

The creep feeding by zeranol interactions significantly affected calf weight at 30, 120, and 190 days of age. Least squares estimates for weights of calves at 190 days of age by creep feeding and zeranol treatment groups are shown in table 14. The data show a tendency for preweaning zeranol implants in the dam to increase calf weight in the noncreep-fed and long-term creep-fed groups and to reduce calf weight in the short-term creep-fed group. However, when values of standard

TABLE 14. LEAST SQUARES ESTIMATES ± SE FOR AVERAGE MILK YIELD, 190-DAY CALF WEIGHT AND CALF WEANING WEIGHT, BY CREEP FEEDING X ZERANOL TREATMENTS

Creep feeding x zeranol combination[a]	Average milk yield kg	190-day calf weight kg	Calf weaning weight kg	Age of calf at weaning days
NC x NZ	5.87 ± .32	186.26 ± 5.70	217.07 ± 7.16	207.28 ± 4.52
NC x Z	5.61 ± .28	192.85 ± 4.86	230.12 ± 6.22	217.81 ± 3.90
SC x NZ	6.22 ± .34	204.97 ± 5.36	225.99 ± 7.89	200.92 ± 5.87
SC x Z	5.58 ± .31	186.91 ± 6.57	212.13 ± 7.47	201.02 ± 6.26
LC x NZ	4.94 ± .29	182.71 ± 5.12	218.25 ± 6.54	214.23 ± 4.17
LC x Z	5.49 ± .29	187.73 ± 5.42	215.09 ± 6.68	209.35 ± 4.15

[a] NC = no creep, SC = short-term creep, LC = long-term creep, NZ = no zeranol, Z = zeranol

errors are considered, most of the differences become unimportant. In most of the cases, weights of the calves for the different creep feeding by zeranol combinations follow the same trend observed in milk production for the same treatments (table 14).

The zeranol by breed of maternal grandsire interactions significantly affected weight of the calves at each milking day. Least squares estimates for weight of the calves by zeranol and breed of maternal grandsire combinations are shown in table 15. Zeranol tended to depress weight of calves from Brahman-sired dams, but tended to increase weight of calves from Romana Red-sired dams. However, given the size of the standard errors of the estimates, the differences in weights would appear to be of little consequence.

Daily weight gains of the calves at various time-intervals during preweaning period are shown in table 16. Creep feeding treatment did not affect significantly the weight gains of calves in any period studied. However, there was a tendency of calves from long-term creep-fed dams to have lower weight gains than calves from noncreep-fed or short-term creep-fed dams. This tendency was most evident in gains up to 70 days of age and followed the same trend observed in milk production for the creep feeding treatments (table 9).

Zeranol treatment of the dam had no effect on weight gain of the calves in the periods studied, and gains from birth to weaning of calves from dams of the two groups were equal (table 16). These results are consistent with the data on milk production of the cows of the two zeranol treatments (table 9).

TABLE 15. LEAST SQUARES ESTIMATES ± SE FOR AVERAGE MILK YIELD, CALF WEIGHT GAIN FROM BIRTH TO WEANING, WEIGHT OF CALF AT 190 DAYS OF AGE, AND HEIGHT OF CALF AT WEANING, BY ZERANOL X BREED OF MATERNAL GRANDSIRE

Zeranol x breed of maternal grandsire combination[a]	Average milk yield kg	190-day calf weight kg	Weight gain from birth to weaning kg	Height at weaning cm
NZ x B	6.35 ± .23	205.63 ± 4.52	.959 ± .021	108.91 ± 1.00
NZ x RR	5.00 ± .26	166.06 ± 5.68	.836 ± .026	102.85 ± 1.25
Z x B	6.39 ± .23	196.30 ± 4.82	.932 ± .022	106.94 ± 1.06
Z x RR	4.70 ± .25	176.06 ± 5.54	.873 ± .025	105.48 ± 1.22

[a] NZ = no zeranol, Z = zeranol, B = Brahman, RR = Romana Red.

TABLE 15. LEAST SQUARES ESTIMATES ± SE FOR CALF DAILY WEIGHT GAIN (KG)

Source of variation[a]	Birth to 30 days	30 to 70 days	70 to 120 days	120 to 190 days	Birth to weaning
Creep treatment of dam					
No Creep (NC)	.919 ± .059	.749 ± .029	.881 ± .034	.899 ± .029	.904 ± .011
Short term (SC)	.725 ± .081	.757 ± .034	.844 ± .066	.921 ± .028	.921 ± .020
Long-term (LC)	.641 ± .036	.703 ± .026	.859 ± .034	.832 ± .023	.882 ± .051
Zeranol treatment of dam					
No zeranol	.667 ± .051	.748 ± .025	.823 ± .038	.937 ± .021	.903 ± .015
Zeranol	.659 ± .029	.719 ± .029	.866 ± .029	.910 ± .018	.903 ± .019
Breed of maternal grandsire					
Brahman	.799 ± .029**	.766 ± .023*	.972 ± .028**	.957 ± .018ᵃ	.941 ± .019***
Romana Red	.517 ± .031	.704 ± .026	.791 ± .051	.891 ± .021	.865 ± .019
Breed group of maternal grandam					
Angus	.658 ± .051	.745 ± .026	.893 ± .031*	.934 ± .021	.884 ± .015ᵃ
F1 Angus Brown Swiss	.619 ± .030	.727 ± .024	.836 ± .026	.951 ± .018	.921 ± .014
Sex					
Male	.705 ± .039	.766 ± .033	.879 ± .036	.918 ± .025**	.930 ± .010ᵃ
Female	.635 ± .011	.729 ± .032	.828 ± .036	.846 ± .025	.879 ± .019
Age of dam					
2 years	.919 ± .026***	.651 ± .022***	.781 ± .029*	.886 ± .017ᵃ	.831 ± .019***
3 years	.108 ± .048	.918 ± .048	.912 ± .049	.963 ± .032	.974 ± .006
Year					
1983	.678 ± .048	.779 ± .042ᵃ	.832 ± .046*	.939 ± .032ᵃ	.920 ± .014
1984	.685 ± .025	.959 ± .022	.881 ± .031	.866 ± .011	.866 ± .013

ᵃP ≤ .10
*P ≤ .05
**P ≤ .01
***P ≤ .001

[a] Zeranol x breed of maternal grandsire interaction affected (P < .10) weight gain in the three successive periods from birth to 120 days of age. Breed of maternal grandsire x breed group of maternal grandam interaction affected (P < .05) weight gain from 30 to 70 days of age. Creep feeding x zeranol x breed of maternal grandsire interactions affected gain from 120 to 190 days of age (P < .05) and from birth to weaning (P < .10). Creep feeding x zeranol x breed group of maternal grandam affected (P < .05) gain from 120 to 190 days of age and from birth to weaning.

Calves from Brahman-sired dams gained significantly faster than calves from Romana Red-sired dams in all periods to weaning (table 16). This is supported by the higher milk yield of the Brahman-sired dams at all milking days (table 9), and also may be explained partially by the higher potential for growth of the Brahman breed in relation to the Romana Red breed.

Calves produced by dams from Angus-Brown Swiss F_1 dams, in general, gained faster than calves produced by dams from Angus dams. The difference in weight gain between the two groups tended to become more apparent as the age of calf increased. As age of calf increases, the milk production of the dam decreases and the calves are less dependent on their dam's milk. This indicates that some difference in genetic potential for gain provided by the Brown Swiss component, which was 12.5% of the genetic component of the calf, still had an effect on growth.

Differences in weight gain were higher for male calves from 120 to 190 days of age ($P < .01$) and from birth to weaning ($P < .10$). Steer calves tended to gain faster than heifer calves at all periods studied, but differences became more evident as age increased.

Calves from 3-year-old dams gained significantly faster than calves from 2-year-old dams at all periods studied, however, the difference in daily weight gain between the two groups tended to decrease at each successive period as the age of calf increased. These results were to be expected, since production of milk by cows of both age groups decreased as the lactation period progressed and, at the same time, the calves became less dependent on milk.

Year affected daily gain of calves from 30 to 190 days of age, but did not significantly affect daily weight gain from birth to weaning.

The zeranol by breed of maternal grandsire interactions affected ($P < .20$) daily weight gain of calf during the three successive periods from birth to 120 days of age. To observe the trend of the effect of these interactions on gain up to weaning, least squares estimates for daily weight gain from birth to weaning by zeranol and breed of maternal grandsire groups are shown in table 15. There was a slight tendency for zeranol to cause a decrease in weight gain of calves from Brahman-sired dams and an increase in weight gain of calves from dams sired by Romana Red bulls over those from dams that were not implanted preweaning with zeranol.

The creep feeding by breed of maternal grandsire interactions affected ($P < .05$) calf daily gain from 120 to 190 days of age and from birth to weaning ($P < .10$). Least squares estimates for daily gain from birth to weaning by creep feeding, zeranol, and breed of maternal grandsire groups are shown in table 17. In the noncreep-fed group, zeranol implants tended to increase weight gain of calves from Brahman-sired dams and decrease weight gain of calves from Romana Red-sired dams. In the short- and long-term creep-fed groups, zeranol implants tended to reduce the weight gains of calves from Brahman sired-dams and to increase the weight gain of calves from Romana Red-sired dams.

The creep feeding by zeranol by breed group of maternal grandam interactions affected ($P < .05$) calf gain from 120 to 190 days of age and from birth to weaning. Least squares estimates for weight gain

TABLE 17. LEAST SQUARES ESTIMATES ± SE FOR AVERAGE MILK YIELD AND CALF DAILY WEIGHT GAIN FROM BIRTH TO WEANING, BY CREEP FEEDING X ZERANOL X BREED OF MATERNAL GRANDSIRE COMBINATION

Creep feeding x zeranol x breed of maternal grandsire[a]	Average milk yield kg	Calf daily weight gain from birth to weaning kg
NC x NZ x B	5.55 ± .45	.905 ± .037
NC x NZ x RR	5.79 ± .45	.885 ± .038
NC x Z x B	6.67 ± .35	.961 ± .030
NC x Z x RR	4.55 ± .45	.866 ± .037
SC x NZ x B	7.05 ± .46	1.036 ± .041
SC x NZ x RR	5.39 ± .50	.845 ± .042
SC x Z x B	6.54 ± .39	.922 ± .035
SC x Z x RR	4.62 ± .51	.823 ± .045
LC x NZ x B	6.06 ± .37	.967 ± .030
LC x NZ x RR	3.81 ± .45	.779 ± .041
LC x Z x B	5.97 ± .46	.915 ± .038
LC x Z x RR	5.00 ± .38	.870 ± .032

[a] NC = no creep, SC = short-term creep, LC = long-term creep, NZ = no zeranol, Z = zeranol, B = Brahman, RR = Romana Red.

from birth to weaning, by creep feeding, zeranol, and breed group of maternal grandam combinations are shown in table 18. In the short- and long-term creep-fed groups of cows from Angus dams, zeranol implants tended to increase weight gain of the calves, while in the noncreep-fed group of cows from Angus dams, zeranol implants tended to reduce weight gain of the calves. In the noncreep-fed and long-term creep-fed dams from Angus-Brown Swiss F_1 dams, zeranol implants tended to increase weight gain of the calves, but in the short-term creep-fed dams from Angus-Brown Swiss F_1 dams, zeranol implants tended to reduce weight gain of the calves. Differences within creep feeding, zeranol, breed group of maternal grandam were small, however, when standard errors of estimates are considered and, in general, followed the same trends observed for milk yields among treatment groups (table 18).

Least squares estimates for actual weaning weight, 205-day weight, age at weaning, and hip height at weaning of calves are shown in table 19. Actual weaning weight of the calf is the weight of greatest economic importance to the commercial cow-calf producer, since it is the main factor determining the value of the calf. Calf weaning weight is a product of birth weight, preweaning daily weight gain, and age of the calf at weaning. Actual weaning weight of calves from noncreep-fed dams did not differ ($P > .10$) from that of calves from creep-fed dams. These results do not concur with results reported by Holloway and Totusek (1973b). The tendency for a higher weight gain observed for calves from short-term creep-fed dams, in comparison to calves from long-term creep-fed dams, did not result in any difference in actual weaning weight between calves from the two

TABLE 18. LEAST SQUARES ESTIMATES ± SE FOR AVERAGE MILK YIELD AND CALF DAILY WEIGHT GAIN FROM BIRTH TO WEANING, BY CREEP FEEDING X ZERANOL X BREED GROUP OF MATERNAL GRANDAM

Creep feeding x zeranol x breed group of maternal grandam[a]	Average milk yield kg	Calf daily weight gain from birth to weaning kg
NC x NZ x A	5.97 ± .45	.923 ± .037
NC x NZ x SA	5.77 ± .45	.867 ± .038
NC x Z x A	5.13 ± .44	.873 ± .035
NC x Z x SA	6.09 ± .34	.963 ± .029
SC x NZ x A	5.46 ± .59	.838 ± .051
SC x NZ x SA	6.98 ± .42	1.043 ± .036
SC x Z x A	5.48 ± .42	.904 ± .038
SC x Z x SA	5.68 ± .46	.897 ± .041
LC x NZ x A	4.77 ± .45	.905 ± .037
LC x NZ x SA	5.11 ± .38	.841 ± .032
LC x Z x A	5.11 ± .45	.860 ± .037
LC x Z x SA	5.87 ± .39	.924 ± .034

[a] NC - no creep, SC = short-term creep, LC = long-term creep, NZ = no zeranol, Z = zeranol, A = Angus, SA = F_1 Angus-Brown Swiss.

TABLE 19. LEAST SQUARES ESTIMATES ± SE FOR CALF TRAITS AT WEANING

Source of variation[a]	Actual weaning weight kg	205-day adjusted weaning weight kg	Weaning age days	Hip height cm	Condition score
Creep treatment[b]					
No creep (NC)	223.09 ± 6.20	216.54 ± 6.01	212.54 ± 6.10	108.61 ± .86	0.59 ± .17
Short-term (SC)	208.16 ± 6.62	220.65 ± 6.58	200.91 ± 6.66	105.12 ± 1.36	0.25 ± .21
Long-term (LC)	218.06 ± 4.07	211.95 ± 6.05	215.88 ± 3.88	105.61 ± .86	0.66 ± .17
Zeranol treatment					
No zeranol	223.66 ± 6.12	216.55 ± 3.61	207.67 ± 3.01	105.06 ± .85	0.38 ± .15
Zeranol	218.19 ± 3.86	215.08 ± 3.30	209.08 ± 3.36	106.21 ± .87	0.45 ± .15
Breed of maternal grandsire					
Brahman	235.18 ± 6.04***	226.02 ± 6.28***	216.71 ± 2.02**	101.06 ± .77**	0.73 ± .16*
Romana Red	206.41 ± 6.16	205.94 ± 6.54	202.03 ± 6.40	104.11 ± .97	0.10 ± .16
Breed group of maternal grandam					
Angus	212.09 ± 6.15+	212.17 ± 3.06+	204.34 ± 3.35+	108.62 ± .92+	0.46 ± .19
F_1 Angus/Brown Swiss	227.11 ± 6.03	220.50 ± 3.05	212.22 ± 2.66	107.07 ± .66	0.33 ± .16
Sex					
Male	226.34 ± 6.26+	223.63 ± 6.11**	205.45 ± 6.16	111.26 ± .92*	0.35 ± .17
Female	213.20 ± 6.15	209.23 ± 6.11	210.06 ± 6.10	106.02 ± .66	0.66 ± .17
Age of dam					
2 years	206.62 ± 3.51***	199.26 ± 2.80***	211.11 ± 2.10	104.47 ± .61*	0.15 ± .12*
6 years	233.60 ± 8.16	240.52 ± 5.61	204.02 ± 4.21	101.68 ± 1.18	0.06 ± .23
Year					
1983	221.25 ± 6.66	221.10 ± 5.03+	206.76 ± 6.20	106.05 ± 6.17	0.86 ± .23+
1984	216.35 ± 6.46	211.06 ± 2.76	211.77 ± 2.23	106.04 ± .66	0.16 ± .12

+P < .10
*P < .05
**P < .01
***P < .001

[a] The creep feeding × zeranol interaction affected (P < .10) weaning weight. Creep feeding × breed of maternal grandsire × breed group of maternal grandam interactions affected weaning weight (P < .05) and age at weaning (P < .10). The 205-day adjusted weaning weight was affected by the interactions creep feeding × zeranol × breed of maternal grandsire (P < .10) and creep feeding × zeranol × breed group of maternal grandam (P < .05). The interaction zeranol × breed of maternal grandsire affected (P < .05) height of calf at weaning.

[b] Calves from LC dams were older (P < .10) than those from SC dams.

groups of dams. This lack of a difference was due to the younger age at weaning of calves from the short-term creep-fed dams (table 19).

No difference was observed in weaning weight of calves from dams of the two zeranol treatment groups. Since calves from the two treatment groups had the same average daily gain to weaning and had almost equal ages at weaning, no difference was expected. No scientific data were found in the literature on the effects of zeranol implants in heifers during the preweaning phase on the weaning weight of their progeny.

Calves from Brahman-sired dams were heavier ($P < .001$) at weaning than calves from Romana Red-sired dams, as a result of being older at weaning ($P < .001$) and having a higher rate of gain during the preweaning period. Calves from Brahman-sired dams were older at weaning as the result of a higher proportion of heifers of this breed group cycling at beginning of the first breeding season (Study 1), which permitted a larger number of these heifers to become pregnant early in the breeding season.

Calves produced by dams from Angus-Brown Swiss F_1 cows were heavier ($P < .10$) at weaning than those produced by cows from Angus dams, again as a result of their higher daily weight gain ($P < .10$) and because they were older ($P < .10$) at weaning. The greater age at weaning of calves produced by dams from F_1 cows may be explained also as the result of a higher proportion of heifers from F_1 dams reaching puberty and cycling prior to the beginning of their first breeding season (Study 1).

Steer calves were heavier ($P < .10$) at weaning than the heifers. This agrees with most reported results, including those from Koch and

Clark (1955), Laster et al. (1973), Pell and Thayne (1978), and Euclides (1984). In this study sex did not significantly affect age at weaning.

Calves from 3-year-old dams were heavier ($P < .001$) at weaning than calves from 2-year-old dams, in agreement with almost all results previously reported. Calves from 3-year-old dams tended, however, to be younger than calves from 2-year-old dams. This result shows that lactating 2-year-old heifers tended to become pregnant later in the breeding season than did the yearling heifers. Negative effects of lactation on time of conception, which were most evident in young animals were reported by Koger et al. (1962) and Reynolds et al. (1979).

Year did not significantly affect actual weaning weight and age of the calves, but did affect ($P < .10$) 205-day weight. This latter was due to the fact that the calves born in 1983 tended to be heavier and younger at weaning than those born in 1984 and when adjusted to a constant age, their weights did differ.

Creep feeding by zeranol interactions affected actual weaning weight of the calves. Least squares estimates for weaning weight of the calves by creep feeding and zeranol treatment groups are shown in table 14. The estimates indicate that, in noncreep-fed cows, zeranol implant tended to increase calf weaning weight, while in short-term creep-fed heifers the zeranol implant tended to reduce weaning weight of the calves.

Creep feeding by breed of maternal grandsire by breed group of maternal grandam interactions affected weaning weight and age of the calves at weaning. Least squares estimates for weaning weight and age of calf at weaning, by creep feeding, breed of maternal grandsire and breed group of maternal grandam groups are shown in table 20. In the noncreep-fed group, heifers from Angus dams and sired by Romana Red bulls tended to wean heavier calves than heifers from F_1 dams sired by Romana Red bulls, while in the two creep-fed groups the opposite was observed for Romana Red-sired calves. Also, in the long-term creep-fed group, heifers from Angus dams and sired by Brahman bulls tended to wean heavier calves than heifers from F_1 dams and sired by Brahman bulls, the opposite was observed for Brahman-sired heifers in the no creep and short-term creep-fed groups. Holding breed of maternal grandsire and breed group of maternal grandam constant, the short-term creep-fed heifers tended to wean heavier calves than heifers from the other two creep treatments, however, in the group of heifers from Angus dams and sired by Romana Red bulls, short-term creep-fed heifers weaned the lightest calves which were also the youngest group at weaning.

The 205-day calf weight is a product of average daily gain to weaning and birth weight; consequently, factors which affect either or both these two components will influence 205-day weight. In this study, calf 205-day weight (table 19) was affected by breed of maternal grandsire ($P < .001$), breed group of maternal grandam ($P < .10$), age of dam ($P < .001$), and year ($P < .10$). In addition, as was observed for daily weight gain, the 205-day weight was affected by the interactions among creep feeding, zeranol, and breed of maternal grandsire ($P < .10$), and creep feeding, zeranol, and breed group of maternal grandam ($P < .05$).

TABLE 20. LEAST SQUARES ESTIMATES ± SE FOR AGE AND WEIGHT OF CALF AT WEANING, BY CREEP FEEDING X BREED OF MATERNAL GRANDSIRE X BREED GROUP OF MATERNAL GRANDAM

Creep feeding x breed of maternal grandsire x breed group of maternal grandam[a]	Average milk yield kg	Calf daily weight gain from birth to weaning kg
NC x B x A	208.67 ± 5.01	217.60 ± 8.61
NC x B x SA	216.51 ± 5.86	244.86 ± 9.07
NC x RR x A	214.18 ± 6.46	224.25 ± 11.32
NC x RR x SA	210.82 ± 5.96	207.68 ± 9.24
SC x B x A	212.47 ± 6.39	234.70 ± 9.07
SC x B x SA	214.53 ± 8.22	250.00 ± 11.83
SC x RR x A	169.23 ± 12.39	168.16 ± 18.71
SC x RR x SA	207.64 ± 6.11	223.68 ± 9.24
LC x B x A	220.92 ± 5.72	233.45 ± 9.49
LC x B x SA	209.14 ± 5.47	230.48 ± 8.57
LC x RR x A	200.56 ± 6.69	196.79 ± 10.39
LC x RR x SA	214.53 ± 5.43	205.93 ± 9.24

[a] NC = no creep, SC - short-term creep, LC = long-term creep, B = Brahman, RR - Romana Red, A = Angus, SA = F_1 Brown Swiss-Angus

Hip height of calves at weaning (table 18) in general showed good agreement with weaning weight and was not affected by creep feeding and zeranol treatments. The factors that significantly affected calf hip height were breed of maternal grandsire, breed group of maternal grandam, sex of calf, and age of dam. Effects of breed of maternal grandsire and grandam on calf hip height was a result of genetic influences on both milk production of dam and frame size of calf, since breed groups which had positive effects on calf hip height (Brahman breed of maternal grandsire and Angus-Brown Swiss F_1 breed group of maternal grandam) were larger framed and had higher milk yields. Steer calves were taller at the hip ($P < .05$) at weaning than were the heifers. Calves from 3-year-old heifers were taller than those from 2-year-old heifers, and this can probably be explained as the result of better pre- and postnatal maternal environment.

Zeranol by breed of maternal grandsire interactions affected hip height of calves at weaning. Least squares estimates for calf hip height at weaning, by zeranol and breed of maternal grandsire are shown in table 15. Calves from zeranol-implanted, Brahman-sired dams tended to be shorter than calves from non-implanted Brahman-sired cows, while the opposite was observed for calves from Romana Red-sired dams. A good agreement existed, however, between height of calves of the different breeds of maternal grandsire and zeranol groups and daily gain from birth to weaning and weight of calves at 180 days of age.

Condition score of the calves at weaning (table 18) was influenced by breed of maternal grandsire ($P < .05$), age of dam ($P < .10$), and year ($P < .10$). Influences of breed of maternal grandsire and age of dam would be a result of higher milk production of Brahman-sired dams in relation to Romana Red-sired dams, and of higher milk production of 3-year-old dams in relation to 2-year-old dams. Year effects involve a complex of factors, such as availability and quality of forages, incidence of parasites and diseases, direct effects of climate on the animal, etc. When subjectively evaluated traits like condition score are considered, year to year variations in human judgment may also be involved.

Partial correlations were determined between average milk yield of the dam and calf traits measured at weaning. Partial correlations observed between average milk yield of the dam and daily gain of calf from birth to weaning, actual weaning weight of calf, calf hip height, and calf condition score were, respectively, .62 ($P < .0001$), .59 ($P < .001$), .40 ($P < .001$), and .29 ($P < .05$). The correlation coefficients between milk yield of dam and calf gain and calf weaning weight in the present study were higher than the values reported by Chenette and Frahm (1981), but are within the range of .42 to .68 reported by many authors (Wistrand and Riggs, 1966; Gleddie and Berg, 1969; Dickey et al., 1970; Reynolds et al., 1978; Robison et al., 1978). Partial correlations of .64 and .56 were observed between average yield of total milk solids of dam and calf weaning weight and calf daily weight gain from birth to weaning, respectively.

Little information exists about repeatability of milk production and calf traits in beef cattle. For this reason, values of repeatability were calculated in this study, in spite of the severe limitations imposed by the very small number of animals involved and by the fact that only two measurements were available per animal

Repeatability of average milk production in this study was .69 ± .10. This value is similar to the value of .61 ± .05 reported for Hereford cows by Neville et al. (1974), but higher than the values of .38 and .46 observed by Rutledge et al. (1972) and Dillard et al. (1978), respectively.

Repeatability for age of calf at weaning was .46 ± .14. This value is much higher than the values of .14 reported by Harwin et al. (1969) for early calving, and .092 and .105 reported by Lemaister et al. (1973). In the present study repeatability was determined on the basis of only two successive observations on each cow, while in the above cited studies the data were collected over a long period and involved information on animals with age varying from 2 to 15 years. Repeatability for 205-day calf weight was .30 ± .21. Neville et al. (1974) reported values of .29 ± .06 and .45 ± .06 for repeatability of 210-day calf weight, and Martin et al. (1970) reported the value of .53 for repeatability of weaning weight. Repeatability of hip height at weaning in the present study was .40 ± .18.

Summary

Data on 97 cow-calf pairs were used to study the effects of creep feeding and zeranol implants during the sucking period on future maternal ability of heifers. The heifers used in this study were born in 1981 and 1982 from Angus (A) and Angus-Brown Swiss F_1 dams (F_1) and sired by Brahman (B) and Romana Red (RR) bulls. Part of the heifers received implant of 36 mg of zeranol at approximately 56 days of age and again 90 days later. Three levels of creep feeding were used, including no creep feeding (NC), creep feeding from approximately 146 days of age to weaning (SC), and creep feeding from approximately 56 days of age to weaning (LC). The experimental animals were mated in multi-sire herds to Polled Hereford and Hereford bulls as yearlings and annually thereafter. Quantity and composition of milk produced by the heifers and preweaning performance of their calves were the parameters used to evaluate maternal performance. Milk yield of NC heifers did not differ from the average of SC and LC heifers at days 30, 70, 120, and 190 of lactation, however, LC heifers produced less ($P < .05$) milk than the SC group at days 30 and 70 of lactation and tended to produce less at the subsequent milkings. Creep effects on milk composition were varied. The NC heifers had higher ($P < .10$) percentages of milk fat and total milk solids than creep-fed heifers at day 30 of lactation but lower percentage of milk protein at day 190 of lactation. The NC heifers did not differ from the average of the creep-fed groups for weight and weight gain of their calves at any period studied. Likewise their calves did not differ from the average of the other two groups for hip height and condition score at weaning. Calves from LC heifers tended to have lower daily weight gains than calves from NC and SC heifers and were significantly lighter than those from SC heifers at 30, 70, 120, and 190 days of age. There was no significant difference in weaning age of calves from creep-fed and noncreep-fed heifers; however, SC heifers weaned younger ($P < .10$) calves than did LC heifers. Zeranol treatment did not significantly affect milk yield and composition or any calf trait studied. In relation to RR-sired heifers, those sired by B bulls produced significantly more milk at each milking day and produced milk with significantly lower percentages of fat, protein, and total milk solids. Calves from B-sired heifers had significantly higher values for weight and weight gains, and for age, hip height, and condition score at weaning than calves from AA-sired cows. Heifers from F_1 dams produced significantly more milk at days 30, 70, and 190 of lactation and had a higher average milk yield than did heifers from A dams. Milk composition from heifers of the two breed groups did not differ ($P < .10$) at any stage of lactation. Calves produced by heifers from F_1 dams tended to be heavier at 30, 70, 120, and 190 days of age, had higher average daily gains ($P < .10$) from 70 to 120 days of age and from birth to weaning, had higher ($P < .10$) 205-day weights, and were older ($P < .10$), heavier ($P < .10$) and taller ($P < .05$) at weaning than calves produced by heifers from A dams. No difference existed, however, between calves from the two breed groups of dam for condition score at weaning. Three-year-old heifers produced significantly more milk at all milking days than did 2-year-old heifers. Milk from 3-year-old heifers had higher percentages of fat at days 30 and 120, protein at days 30 and 190, and total milk solids at days 30, 70, and 120 of lactation, as well as higher average percentage of fat, protein, and total milk solids than did the milk from 2-year-old heifers. Calves from 3-year-old cows were heavier at all ages up to and including weaning and were taller and fatter at weaning than were the calves from 2-year-old dams. They tended, however, to be younger at weaning. Year was confounded with milking method, length of secretion period, sampling interval and sampling time, and had a highly significant effect on percentage of milk fat and total milk solids, but did not have a consistent effect on milk yield. In addition, year significantly affected percent of protein at day 70 of

lactation, calf weight at birth and at 30 days of age, calf daily gain from 30 to 70, from 70 to 120, and from 120 to 190 days of age, 205-day calf weight, and calf condition score at weaning. Sex of calf did not affect milk yield and composition, however, female calves had significantly lower values for birth weight, weight at milking days, 205-day weight, weight and height at weaning, and weight gain from 120 to 190 days of age and from birth to weaning. Partial correlations between milk yield and calf traits were studied and variation in milk yield and milk constituents during lactation were studied by regression analyses Significant interactions were shown and discussed.

SUMMARY AND CONCLUSIONS

Data collected on 44 heifers born in 1981 and 48 heifers born in 1982, from Angus (A) and Angus-Brown Swiss F_1 (F_1) dams and sired by Brahman (B) and Romana Red (RR) bulls, were used to study the effects of creep feeding and zeranol implants during the suckling period on growth and reproductive performance of beef females. Heifers were mated starting as yearlings in multi-sire herds to Polled Hereford and Hereford bulls during a 60-day breeding season Effects of treatments on quantity and composition of milk produced by the heifers and the preweaning performance of their calves were studied using information from 97 cow-calf pairs. Creep feeding treatments studied were no creep (NC), creep feeding from 146 days of age to weaning (SC), and creep feeding from 56 days of age to weaning (LC). Part of the heifers in each treatment-group were implanted with 36 mg of zeranol at 56 days of age and reimplanted 90 days later. Creep-fed heifers were significantly heavier at all ages studied and had higher condition scores at the beginning of the first breeding season, at the end of the second and third breeding seasons, and at palpation for third pregnancy. The SC females were heavier ($P < .10$) than LC females at the end of the second and third breeding seasons. Creep feeding and zeranol implants significantly increased pelvic area at the beginning of the first breeding season, but the differences were erased prior to first calving. Zeranol implants significantly increased weight of the heifers until palpation for first pregnancy.

reduced ($P < .10$) hip height at palpation for third pregnancy, but did not significantly effect the proportion of heifers cycling at the beginning of the first breeding season or the condition score at any age studied. No differences in pregnancy rate were observed between zeranol treatment groups at first and second breeding seasons, but pregnancy rate was lower ($P < .10$) in the implanted group at the third breeding season. The B-sired heifers were significantly heavier than those sired by RR bulls until the beginning of the second breeding season, were significantly taller at the hip at palpation for first pregnancy, and tended to be heavier and taller at all subsequent ages. The B-sired heifers had significantly higher body condition scores than RR-sired heifers at the beginning and end of the first breeding season. Pelvic area was significantly larger at the beginning of the first breeding season in B-sired heifers and those from F_1 dams than in heifers sired by RR bulls and those from A dams. The differences between breed groups of dam still existed at the measurement made prior to first calving at 2 years of age. A higher proportion ($P < .001$) of B-sired heifers and of those from F_1 dams ($P < .01$) were cycling at the beginning of the first breeding season than of RR sired heifers and those from A dams. No differences in pregnancy rates were observed between breed groups of sire or dam. Heifers from F_1 dams were significantly heavier than those from A dams until palpation for first pregnancy, were significantly taller, and tended to have a lower condition score at all ages studied.

Milk yield of NC heifers did not differ from the average of SC and LC heifers at days 30, 70, 120, and 190 of lactation; however, LC heifers produced less ($P < .05$) milk than the SC group at days 30 and

70 of lactation and tended to produce less at subsequent milkings. Creep feeding effects on milk composition were varied. The NC heifers had higher ($P < .10$) percentages of milk fat and total milk solids than creep-fed heifers at day 30 of lactation but lower percentage of milk protein at 190 days of lactation. Weight and weight gain of the calves from NC heifers did not differ from the average of the creep-fed groups at any period studied. Likewise, the calves did not differ from the average of the other two groups for hip height and condition score at weaning. Calves from LC heifers tended to have lower daily weight gains than calves from NC and SC heifers and were significantly lighter than those from SC heifers at 30, 70, 120, and 190 days of age. There was no significant difference in weaning age of calves from creep-fed and noncreep-fed heifers, however, SC heifers weaned younger ($P < .10$) calves than did LC heifers. Zeranol treatment did not significantly affect milk yield and composition or any calf trait studied. In comparison with RR-sired heifers, those sired by B bulls produced significantly more milk at each milking day and produced milk with significantly lower percentages of fat, protein, and total solids. Calves from B-sired heifers had significantly higher values for weight and weight gains, and for age, hip height, and condition score at weaning than calves from RR-sired heifers. Heifers from F_1 dams produced significantly more milk at days 30, 70, and 190 of lactation and had a higher average milk yield than did heifers from A dams. Milk composition from heifers of the two breed groups of dam did not differ ($P > .10$) at any stage of lactation. Calves produced by heifers from F_1 dams tended to be heavier at 30, 70, 120, and 190 days of age, had higher average daily gains ($P < .10$) from 70 to 120

days of age and from birth to weaning, had higher ($P < .10$) 205-day weights and were older ($P < .10$), heavier ($P < .10$), and taller ($P < .05$) at weaning than calves produced by heifers from A dams. No difference existed, however, between calves from the two breed groups of dam for condition score at weaning. Three-year-old heifers produced significantly more milk at all milking days than did 2-year-old heifers. Milk from 3-year-old heifers had higher percentages of fat at days 30 and 120, protein at days 30 and 190, and total solids at days 30, 70, and 120 of lactation, as well as a higher average percentage of fat, protein, and total solids than did the milk from 2-year-old heifers. Calves from 3-year-old dams were heavier at all ages up to and including weaning and were taller and fatter at weaning than were the calves from 2-year-old dams. They tended, however, to be younger at weaning.

Sex of calf did not affect milk yield and composition, however, female calves had significantly lower values for birth weight, weight at milking days, 205-day weight, weight and height at weaning, and weight gain from 120 to 190 days of age and from birth to weaning. Partial correlations between milk yield and calf traits were studied and variation in milk yield and milk constituents during lactation were studied by regression analyses. Significant interactions were shown and discussed.

It can be concluded that creep feeding was not advantageous, since it increased the weight of the heifers at all ages studied but did not improve pregnancy rate of yearling heifers, rebreeding, or maternal ability. Long-term creep feeding depressed maternal ability, as compared to short-term creep feeding. Zeranol implant did not affect maternal ability, but tended to increase pregnancy rate of the heifers as yearlings, and reduced rebreeding at 3 years of age. The possibility exists that the negative effect for zeranol on rebreeding of 3-year-old cows was a consequence of the size of the sample studied, but given the importance of cow fertility in the beef industry, results of the present study do not permit one to recommend the use of zeranol in replacement heifers. More research is necessary on the subject. The Brahman breed was demonstrated to be a better option for crossbreeding with Bos taurus cattle than the Romana Red breed, under the conditions of the present work. Heifers from F_1 dams were more desirable than those from Angus dams, because they weaned heavier calves, calved earlier, and had similar body weight and fertility.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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